

NCHRP 17-46

A Comprehensive Framework for Safety Investment Decisions

Project Overview



Transportation leadership you can trust.

NCHRP 17-46 Objectives

- Develop a comprehensive analysis framework for 4 E safety investment decisions transferable across federal, state, and local governments
- Evaluate the framework's effectiveness

NCHRP 17-46 Report Provides

- Conceptual framework for better integrating 4 E strategy cost-effectiveness comparisons into safety investment decision-making processes
- Methods (a quantitative method and a sketch method) for conducting cost-effectiveness comparisons across the 4 Es of safety

Research can be Applied in Several Contexts

- Strategic Planning
- Prioritization of Applications for Grant Funding
- Corridor Planning

Final Report Contents – Overview

- Conceptual framework
- Two safety project prioritization methods
 - » Quantitative method and example application
 - » Sketch method and two example applications
- Additional reference materials
 - » Supporting resources
 - » Marketing materials

Conceptual Framework

Establish Leadership and Institutional Support

- Engage appropriate stakeholders across safety disciplines
- Establish leadership support for allocating resources towards cost effective solutions

Develop 4E Solutions

- Define the population of injuries and fatalities to be addressed and possible solutions
- Consider all types of strategies across a range of disciplines

Compare and Prioritize

- Analyze and compare the cost-effectiveness of solutions in reducing injuries and fatalities
- Prioritize solutions based on cost effectiveness and other considerations

Implement and Evaluate

- Implement solutions
- Evaluate results and monitor over time

Conceptual Framework Step I: Establish Leadership

- Existing organization
- New organization
- Partnership

Actions to Establish Leadership

- Make safety a top priority
- Maximize funding flexibility and cost effective solutions
- Emphasize the Strategic Highway Safety Plan
- Conduct pilot applications

Goals and Performance Measures

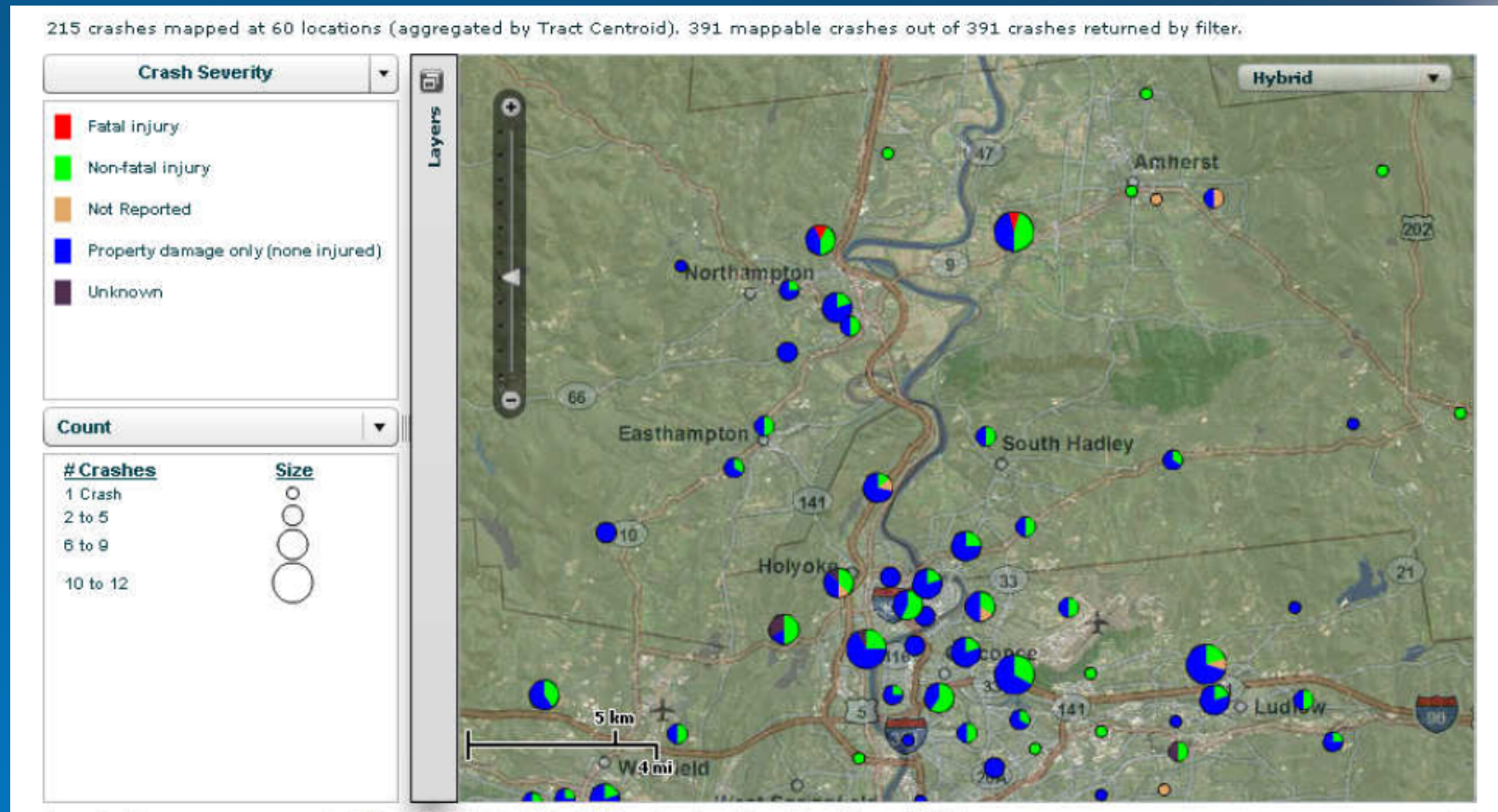
- Develop a shared vision of safety
- Support focus on cost-effective safety planning
- Adopt performance measures to track progress

Framework Step 2: Develop 4E Solutions

- Example Haddon Matrix

	Human Factors	Vehicle Factors	Environmental Factors
Before Crash	Driver experience	Vehicle prone to rollover	High speed limits
During Crash	Alcohol use	Driver ejected	Steep embankment
After Crash	Passenger first-aid skill	Vehicle prone to post-crash fire	Congestion blocks emergency access

Linking all Crashes to the Road Network



Conceptual Framework Step 3: Compare and Prioritize

- Considerations in project prioritization:
 - » Legal Feasibility
 - » Political Support
 - » Technical Capacity
 - » Co-Benefits
 - » Cost
 - » **Cost-Effectiveness and/or Benefit-Cost Ratios**

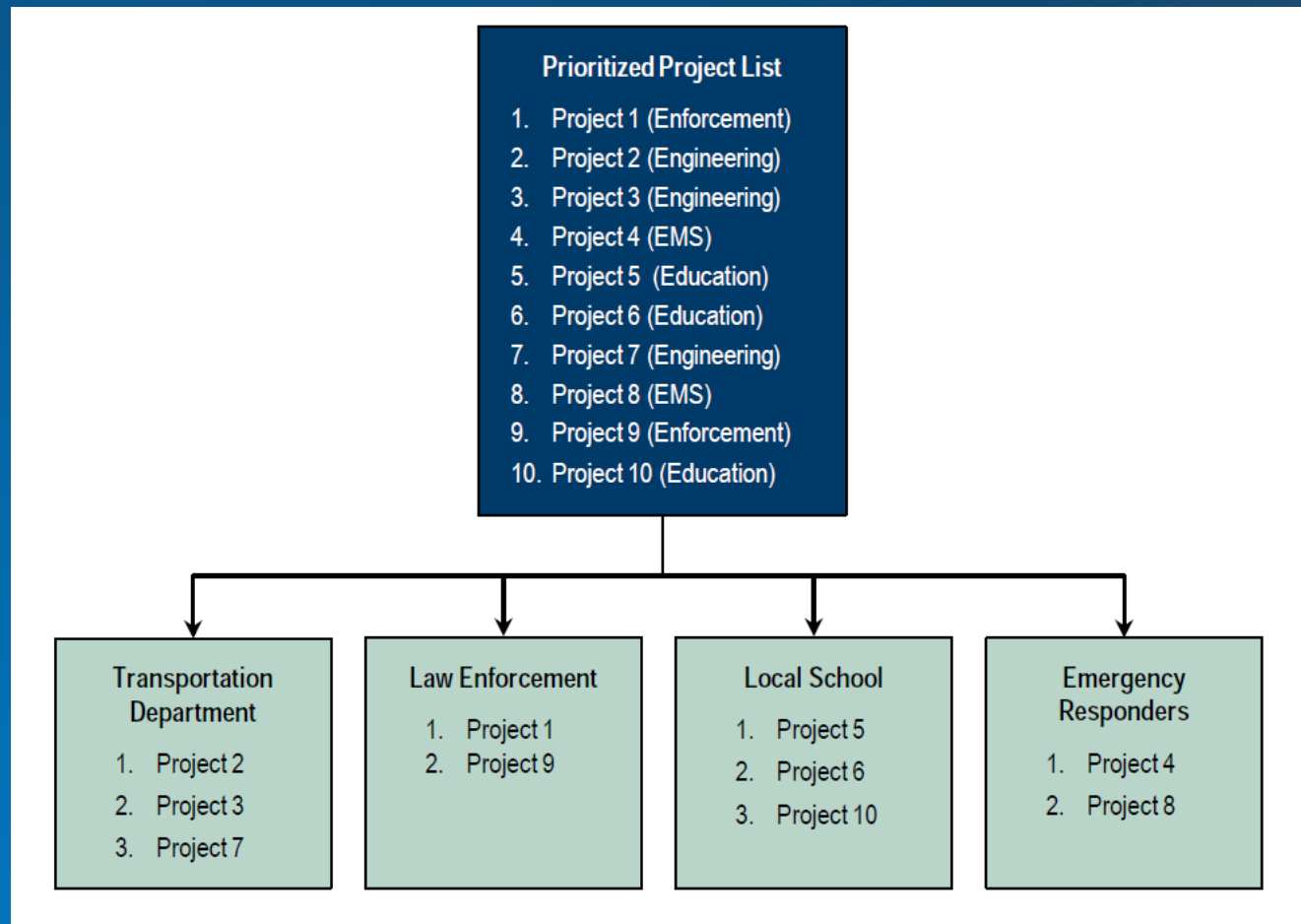
Two Methods for Cost Effectiveness Analysis

	Quantitative Method	Sketch Method
Information Needs	Quantitative assumptions for project cost, duration, geography, effectiveness	Quantitative or qualitative research-based assumptions for project cost, duration, geography, effectiveness
Process	Calculate cost effectiveness	Score projects based on relative cost-effectiveness
Results	Cost effectiveness ratios	Graphic illustration of relative cost effectiveness
Best for	In-depth evaluation of few projects	High-level evaluation of many projects
Contexts	Corridor study, focused policy analysis	Strategic planning

Prioritizing Indirect Strategies

- Traffic data system improvements
- Staff training and development
- Research activities
- Administrative process improvements

Framework Step 4: Implement and Evaluate



Monitoring and Evaluation

(1) Inputs

- Officer time
- Training materials, room rental

(2) Activities

- Train officers to collect better crash data

(3) Outputs

- More complete crash data records
- Fewer errors

(4) Outcomes

- Better ability to identify and address safety problems

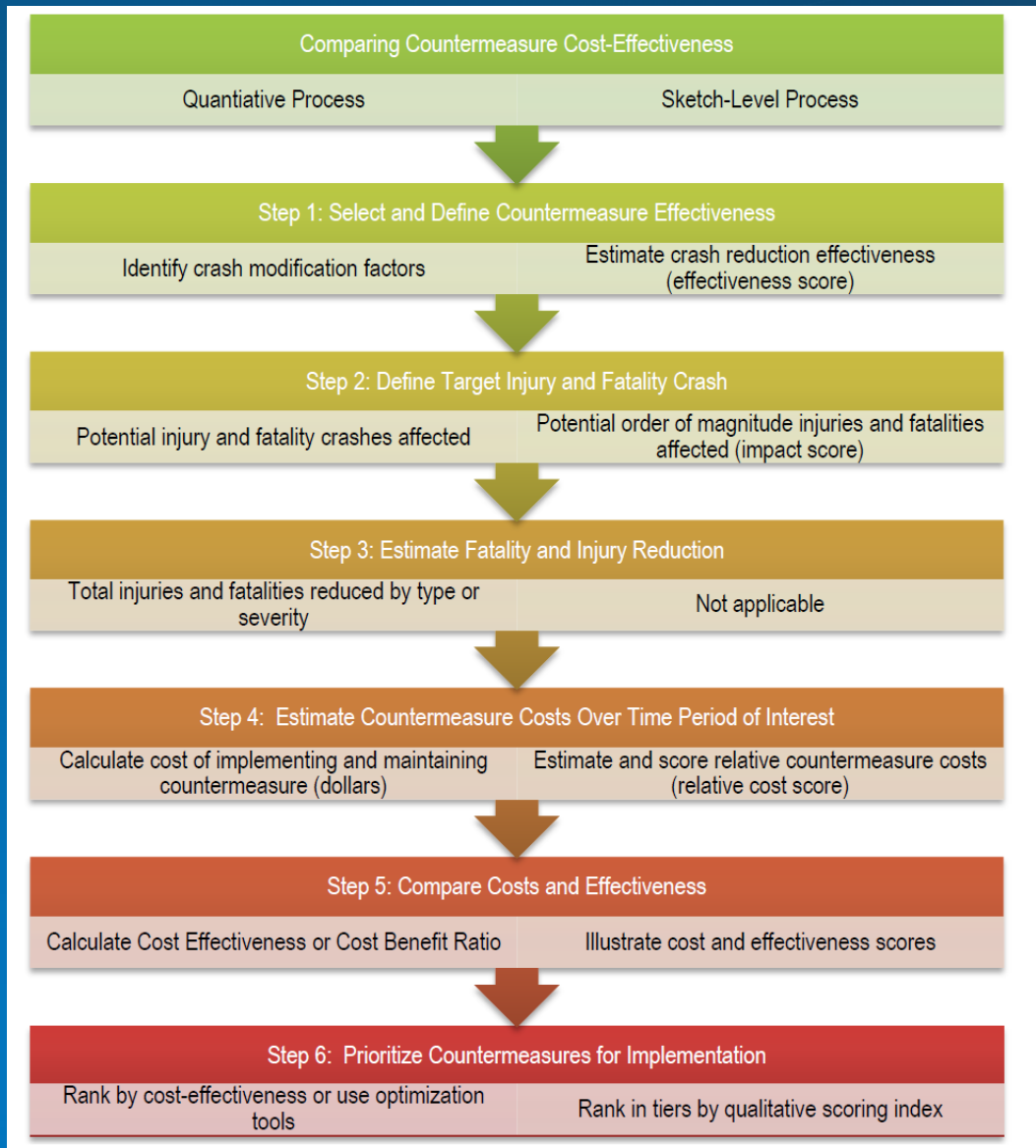
(5) Impact

- Reduced injuries and fatalities

Introduction to the Quantitative and Sketch Methods

- Quantitative method
 - » San Francisco example
- Sketch method
 - » North Carolina example

Review of Steps



I. Define Countermeasure Effectiveness

Identify a CMF

- Highway Safety Manual
- CMF Clearinghouse
- NCHRP 622

Considerations

- Crash severity
- Reduced effectiveness over time
- Combining countermeasures

2. Define Target Crashes

Define Useful Life

- Number of years countermeasure is expected to have quantifiable effect

Define Spatial Effect

- May differ by countermeasure
- Consider spillover effects

2. Define Target Crashes

- Calculate number of crashes per unit time:
 - » Software tools
 - » Highway safety manual (for specific facilities)
 - » Historical crash data.

3. Estimate Crash and/or Injury/Fatality Reduction

- Apply CMF to estimate of future crashes without countermeasure
- Monetize benefits?
 - » Some countermeasures may result in immediate injury and fatality benefits while others may not yield benefits for several years.
 - » Monetization allows calculation of a benefit-cost ratio

4. Estimate Costs

- Timeframe for cost accrual
- Calculate costs
- Convert to present value

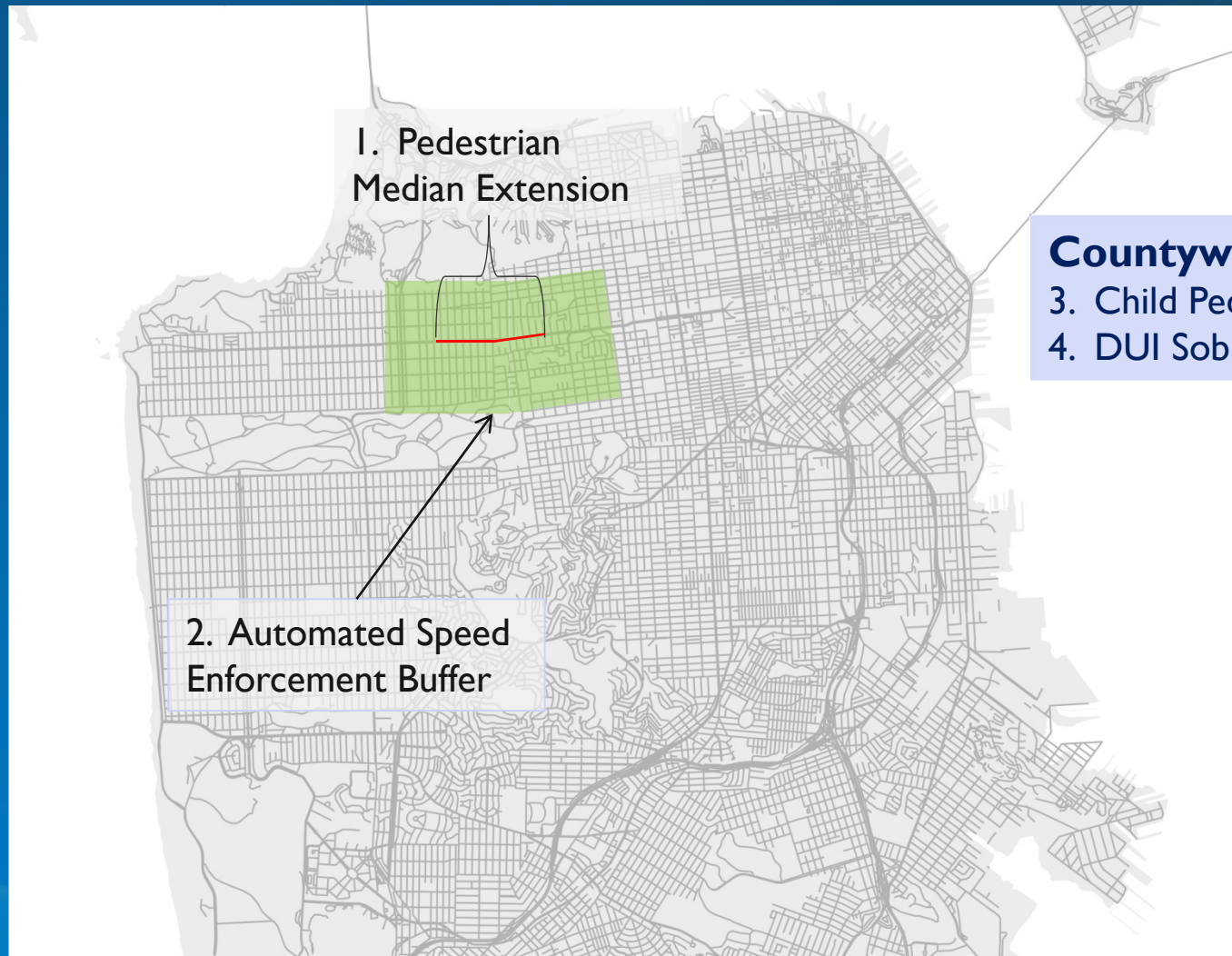
5. Compare Costs and Effectiveness

- Cost effectiveness analysis
- Benefit cost analysis
- Sensitivity analysis

6. Prioritize for Implementation

- Multiple metrics for ranking projects
 - » Monetary value of benefits
 - » Total crashes/injuries/fatalities reduced
 - » Cost-effectiveness index
 - » Net present value
 - » Benefit cost ratio
- Identifying the optimal package typically requires software

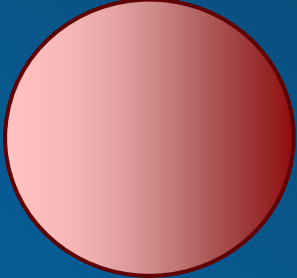



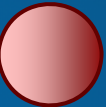



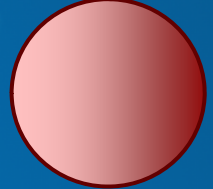



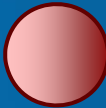



Example Application – San Francisco



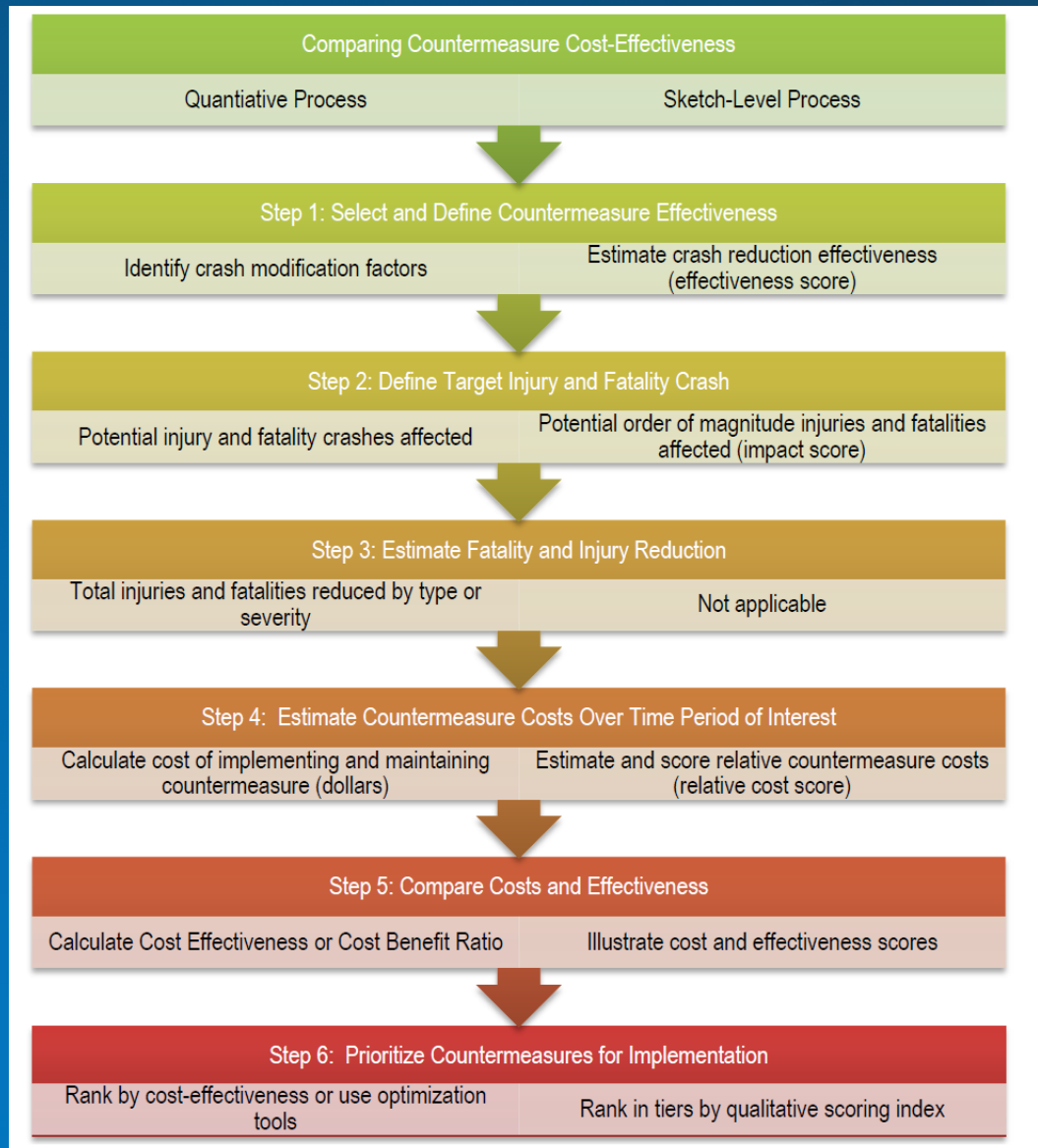
Countywide Implementation

- 3. Child Pedestrian Safety Training.
- 4. DUI Sobriety Check Points.

Application of Quantitative Methods - SF

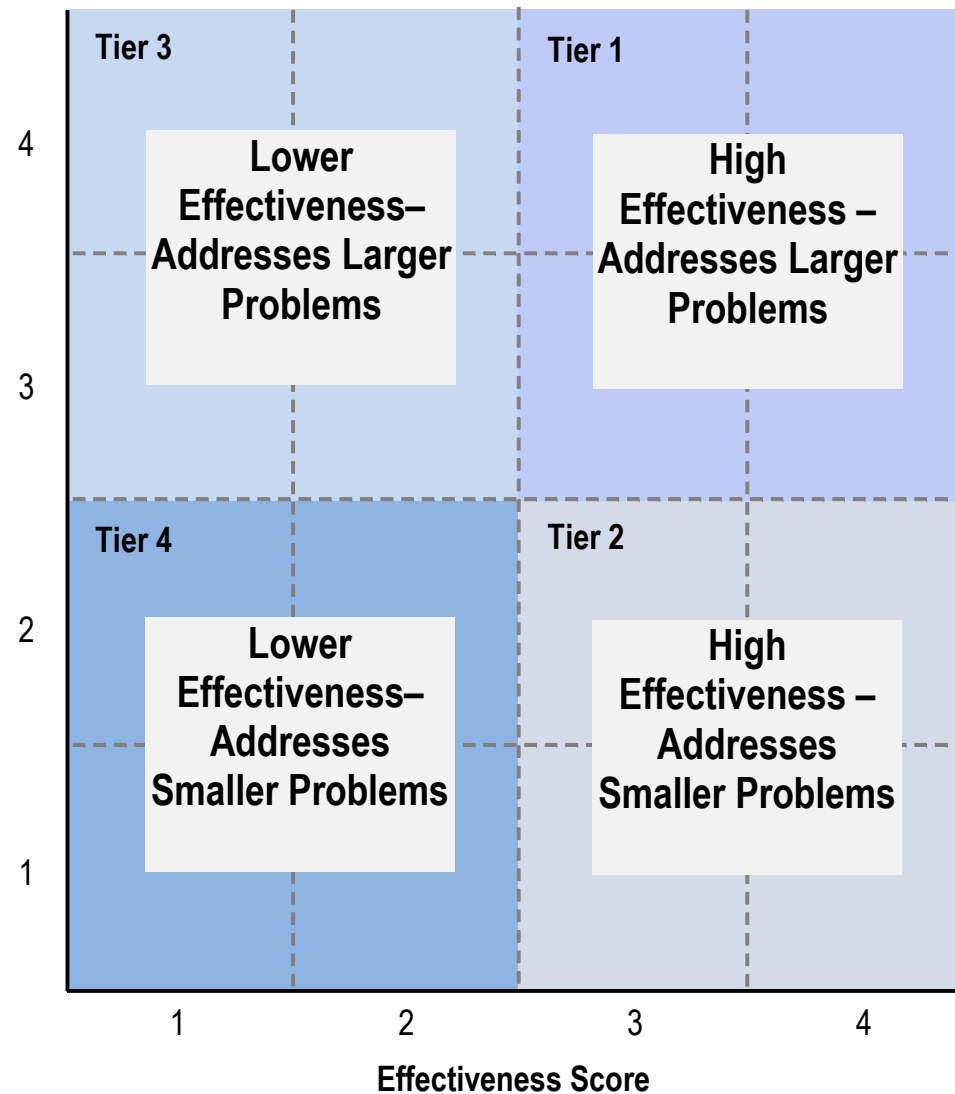
Safety Countermeasure	Benefits	Costs	B-C Ratio (Rounded)
Speed Enforcement	 \$194 Mil	 \$0.7 Mil	  264
Pedestrian Median Extensions	 \$13 Mil	 \$0.2 Mil	  65
Sobriety Checkpoints	 \$86 Mil	 \$5.4 Mil	  16
Pedestrian Trainings	 \$11 Mil	 \$8.5 Mil	  1

Sketch Level Prioritization Method



Sketch Method - Priority Tiers

Problem Score



Sketch Model Example - North Carolina

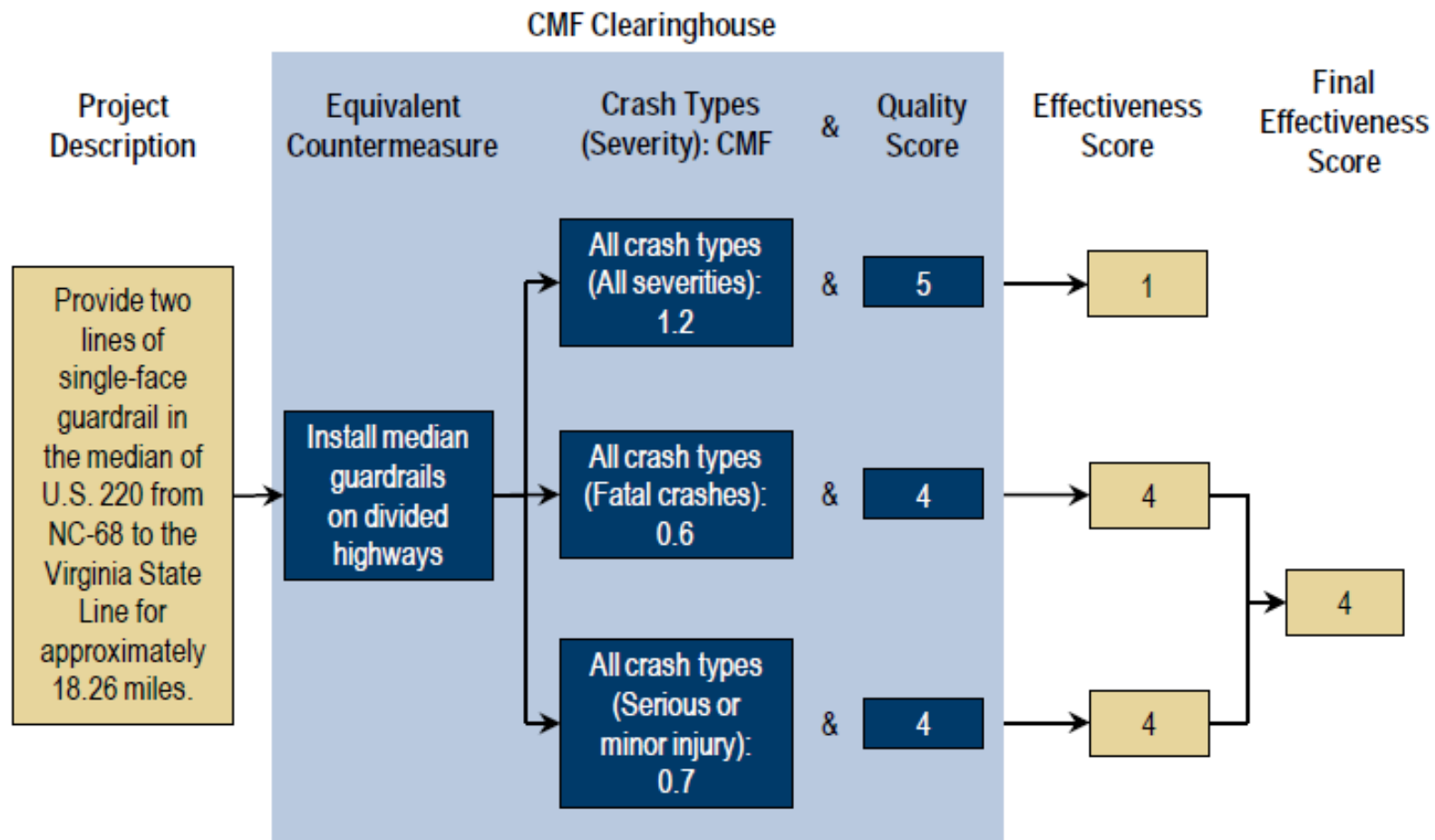
	Project Description	
1	Construct raised median with fencing along Grove Street and provide upgraded pedestrian accommodation	Engineering
2	Provide two lines of single face guardrail on the U.S. 220 median for 18 miles	Engineering
3	Fund national Child Protective Seat classes, provide CPS training, marketing, and seat simulator and equipment	Behavioral
4	Provide a dedicated traffic safety and enforcement unit and educational events	Behavioral

Etc..

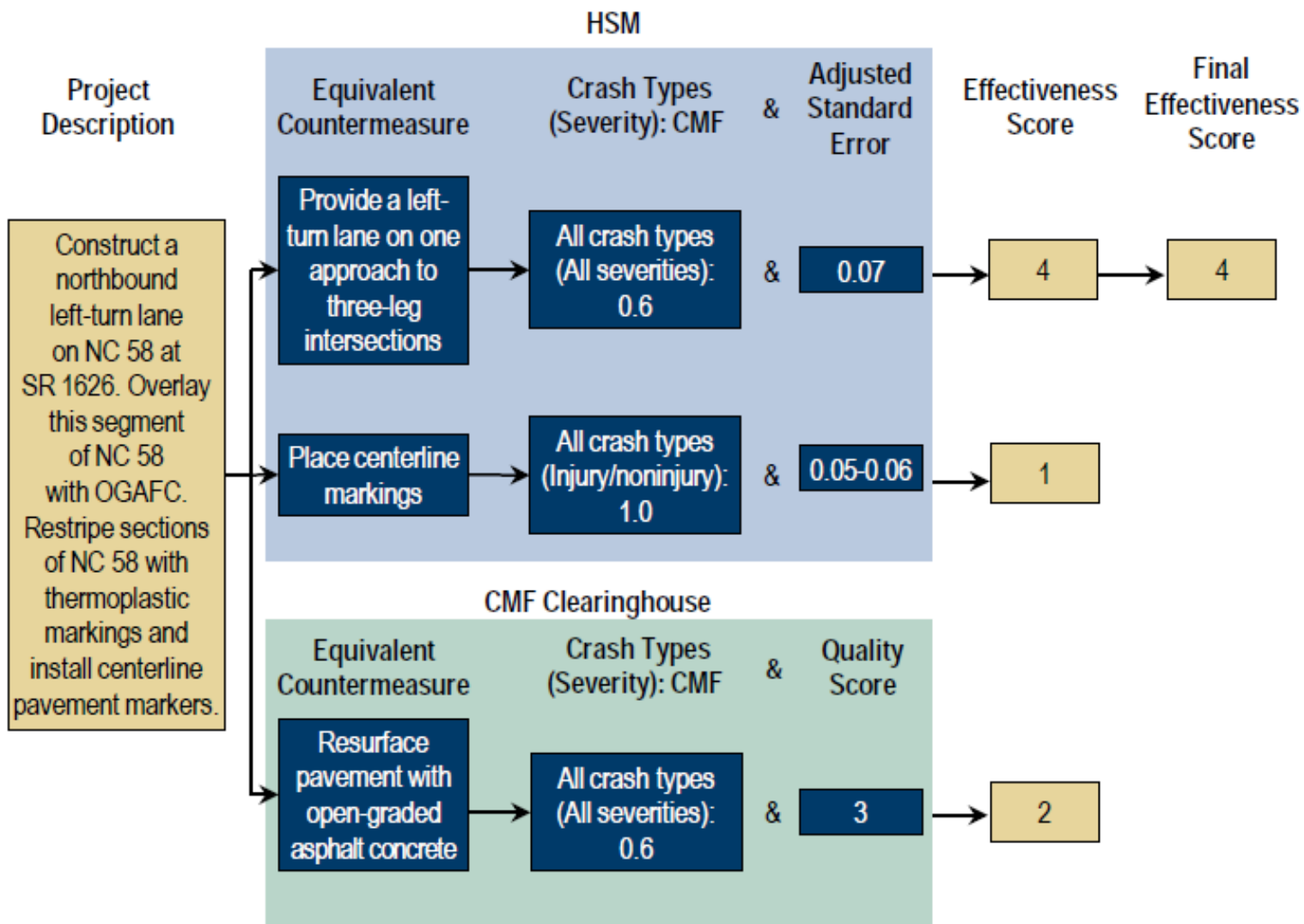
Select Effectiveness Score

	Source	Highly Effective, Proven	Effective, Proven	Somewhat Effective, Unproven	Unknown or Ineffective
Engineering	Crash Modification Factor Clearinghouse	CMF < 0.7 & Quality Score 4-5	$0.7 < \text{CMF} < 1$, & Quality Score 4-5	CMF < 1 , & Quality Score 3	CMF ≥ 1 or Quality Score < 3
	HSM	CMF < 0.7 & Adjusted Standard Error < 0.2	$0.7 < \text{CMF} < 1$ & Adjusted Standard Error < 0.2	CMF < 1 & $0.2 < \text{Adjusted}$ Standard Error < 0.4	CMF ≥ 1 or N/A or Adjusted Standard Error > 0.4 or N/A
Behavioral	Countermeasures that Work	5 stars	4 stars	3 stars	≤ 2 stars or Star Rating Unavailable
	NCHRP 500/NCHRP 17-17(3)		Proven		Tried or Experimental
	NCHRP 622	Proven (Crash Reduction $> 30\%$)	Proven	Likely	Unknown/Uncertain/ Unlikely
Effectiveness Score		4	3	2	1

Engineering Project Effectiveness with Directionally Conflicting CMFs



Engineering Project Effectiveness with Multiple Countermeasure Components



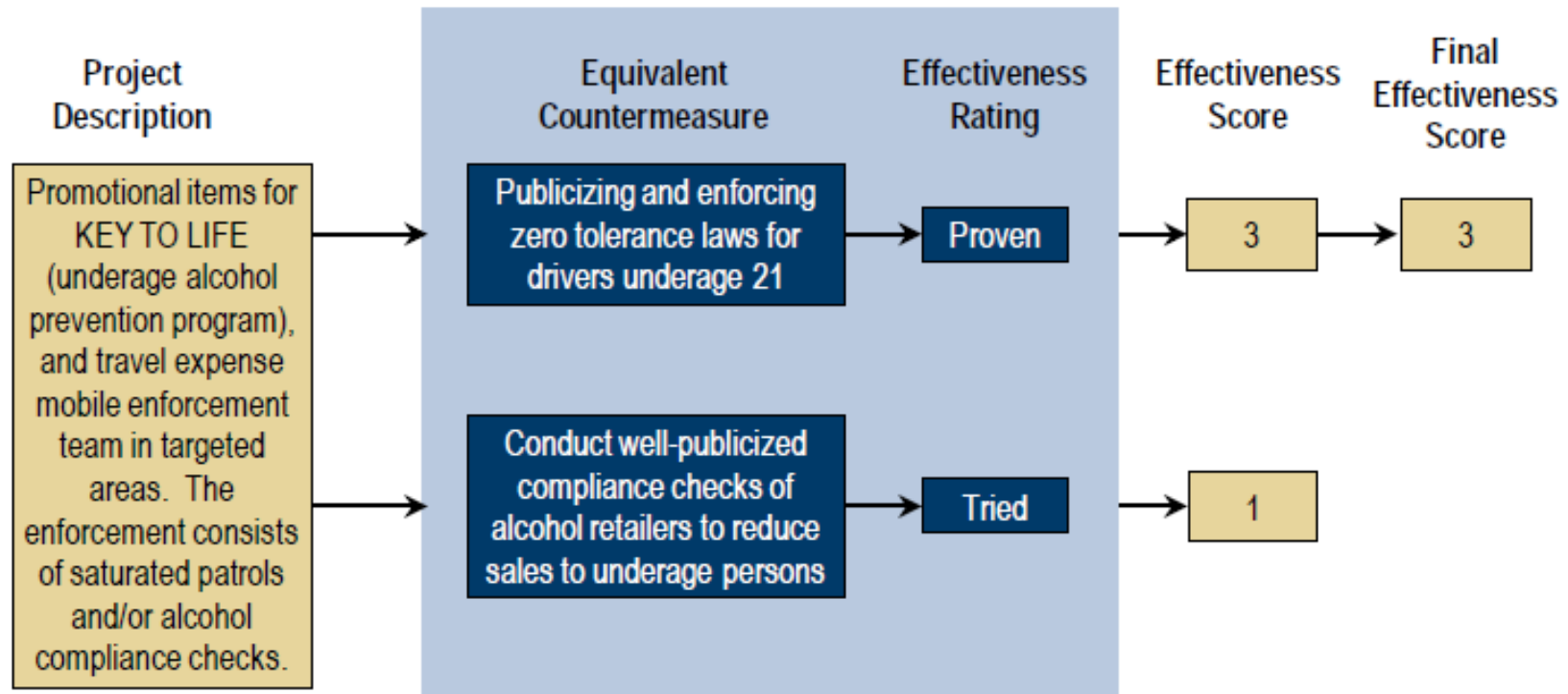
Effectiveness Score of Engineering Projects

Project No.	Project Description	Most Effective Project Component	Source ^a	Setting (Roadway Type)	Crash Type (Severity)	CMF	Adjusted Standard Error (Applies to HSM only)	Quality Score (Applies to CFM Clearinghouse)	Effectiveness Score
1	Raised median and pedestrian improvements	Provide a raised median	HSM	Urban (two lanes)	All types (injury)	0.6	0.1	N/A	4
2	18.26 miles of single face guard rail	Install median guardrails on divided highways	CMF Clearinghouse	Not specified (principal arterial other)	All (fatal)	0.6	N/A	4	4
3	Directional crossover with median U-turn	Replace direct left turn with right turn/U-turn	HSM	Unspecified (unsignalized intersections-access points)	All types (all severities)	0.8	0.1	N/A	3
4	Roundabout in-lieu of existing intersection	Convert stop controlled intersection for a modern roundabout	HSM	Rural (one lane)	All types (all severities)	0.3	0.04	N/A	4



Behavioral Project Effectiveness with Multiple Countermeasure Components

NCHRP Report 500

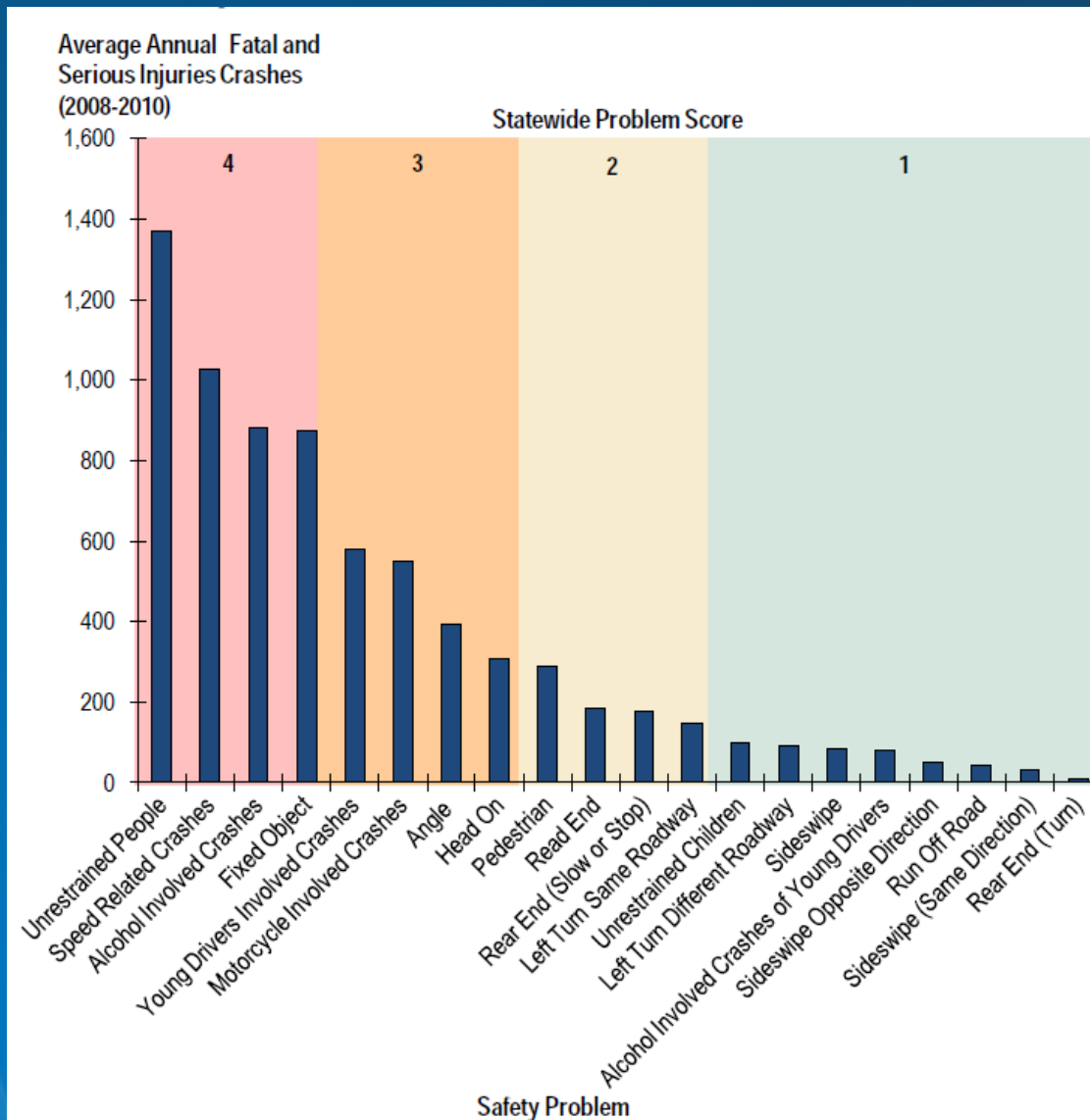


Effectiveness Score of Behavioral Projects

Project No.	Project Description	Most Effective Component(s)	Source of Measures	Effectiveness Rating	Equivalent Effectiveness Score
16	Child protection safety training and outreach	Provide community locations for instruction in proper child restraint use, including both public safety agencies and health care providers that are always available.	NCHRP Report 500: Vol. 11	Tried	1
17	Special needs seat distribution and conference/state fair outreach	Child restraint distribution program	Countermeasures That Work	Two stars	1
		Communications and outreach strategies for booster seat use	Countermeasures That Work	Two stars	
18	Local traffic safety enforcement (seatbelt, speed, and child safety seat)	Conduct highly publicized enforcement campaigns to maximize restraint use	NCHRP Report 500: Vol. 11	Proven	3
		Use targeted conventional speed enforcement programs at locations known to have speeding-related crashes	NCHRP 17-18(3)	Proven	

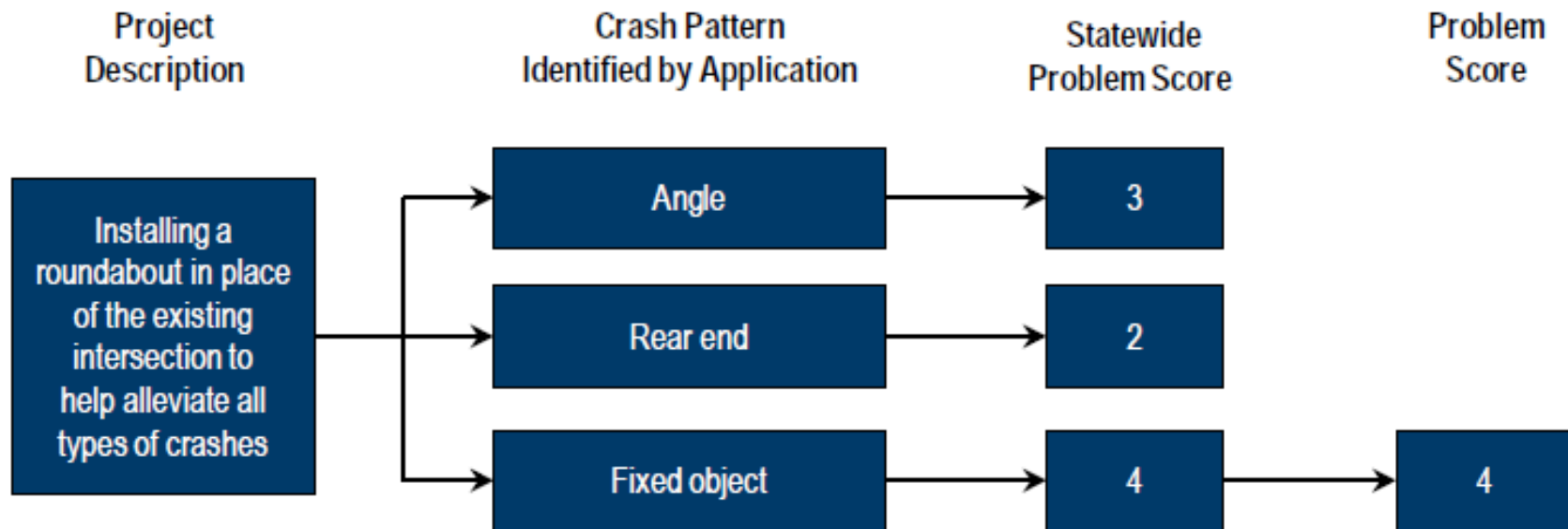


Set Statewide Safety Score



Source: University of North Carolina's crash database

Engineering Project Targeting Multiple Safety Problems



Engineering Project Annualized Cost

Project
Description

Widen NC 27 to provide a
continuous center left-turn lane

Total
Cost

2,350,000

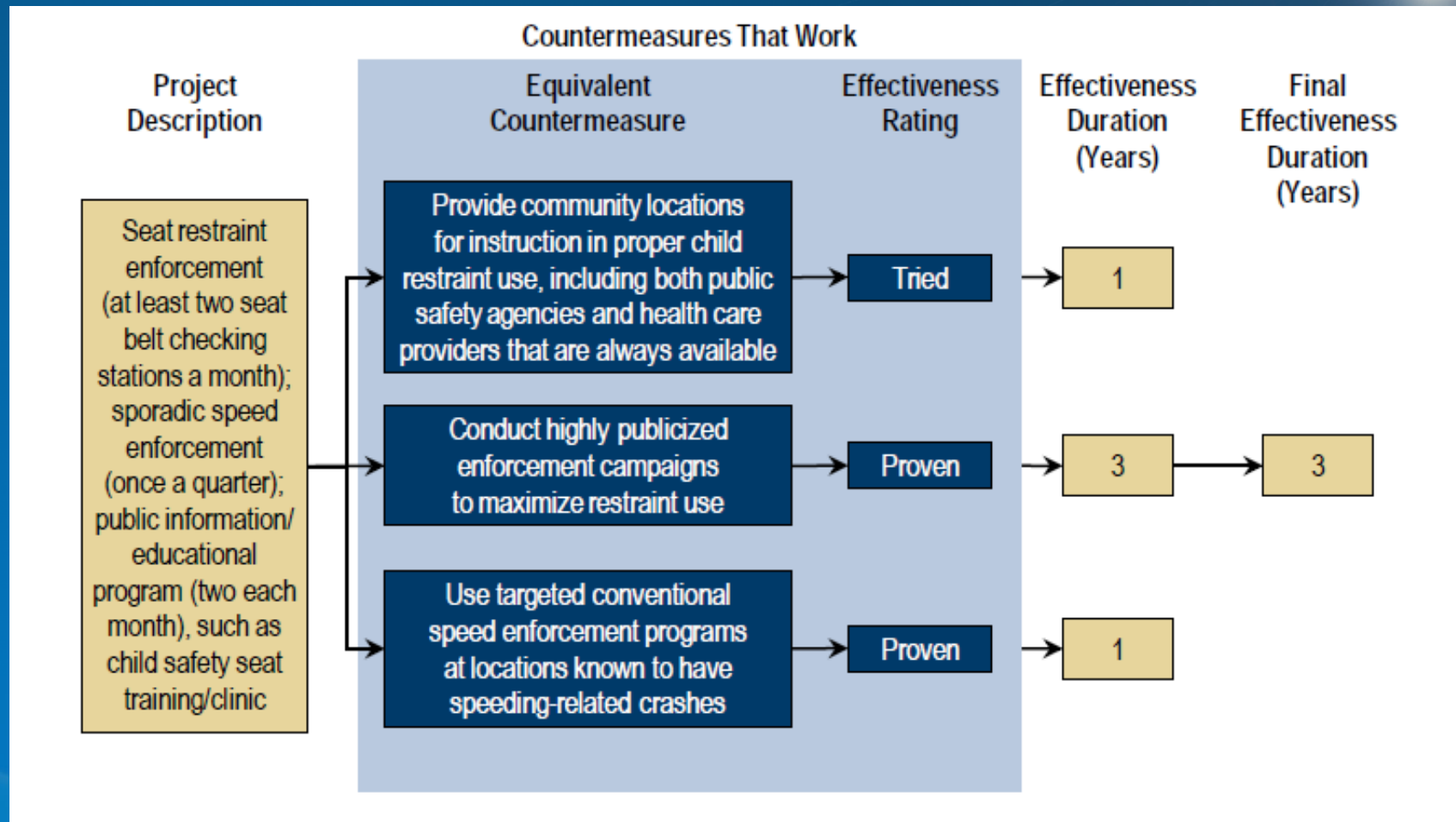
Project
Service Life

21

Annualized
Cost

\$111,905

Behavioral Project Annualized Cost



Cost Score of Engineering Projects

Project No.	Project Description	Total Cost	Project Service Life	Annualized Cost	Cost Score
Engineering Projects					
1	Raised median and pedestrian improvements	1,966,500	30	65,550	2
2	18.26 miles of single face guard rail	3,400,000	15	226,667	3
3	Directional crossover with median U-turn	650,000	20	32,500	1
4	Roundabout in-lieu of existing intersection	650,000	26	25,000	1
5	Left-turn lanes on all approaches and install a traffic signal	314,000	19	16,526	1
6	Provide a continuous center left-turn lane	2,350,000	21	111,905	2
7	Left-turn lane and pavement friction treatment	400,000	17	23,529	1
8	Widen for a third travel lane	1,017,500	20	50,875	2
9	Install raised centerline pavement markers and upgrade existing signage	1,200,000	20	60,000	2



Cost Score of Behavioral Projects

Behavioral Projects					
16	Child protection safety training and outreach	564,129	1	564,129	3
17	Special needs seat distribution and conference/state fair outreach	118,160	1	118,160	2
18	Local traffic safety enforcement (seatbelt, speed, and child safety seat)	16,980	3	5,660	1
19	Dedicated traffic safety unit (traffic safety and DWI enforcement)	93,759	1	93,759	2
20	Purchase in-car video to increase DWI arrest and to use for prosecution	24,000	1	24,000	1
21	BAT mobile unit program (check pts and outreach)	445,000	1	445,000	3
22	Mem units for monitoring high-risk DWI offenders	46,580	1	46,580	1
23	Underage alcohol prevention outreach and enforcement	55,000	1	55,000	2
24	Purchase motorcycles for training and expand motorcycle safety training facility	79,680	1	79,680	2
25	Conduct motorcycle safety check points	28,950	1	28,950	1



Cost Effectiveness of Engineering Projects

Project No.	Project Description	Effectiveness Score	Problem Score	Cost Score
Engineering Projects				
1	Raised median and pedestrian improvements	4	3	2
2	18.26 miles of single face guard rail	4	3	3
3	Directional crossover with median U-turn	3	3	1
4	Roundabout in-lieu of existing intersection	4	4	1
5	Left-turn lanes on all approaches and install a traffic signal	4	3	1
6	Provide a continuous center left-turn lane	4	2	2
7	Left-turn lane and pavement friction treatment	4	2	1
8	Widen for a third travel lane	1	3	2
9	Install raised centerline pavement markers and upgrade existing signage	1	1	2
10	Add two-foot paved shoulders plus a minimum four-foot grass shoulders for 7.4 miles	3	3	3

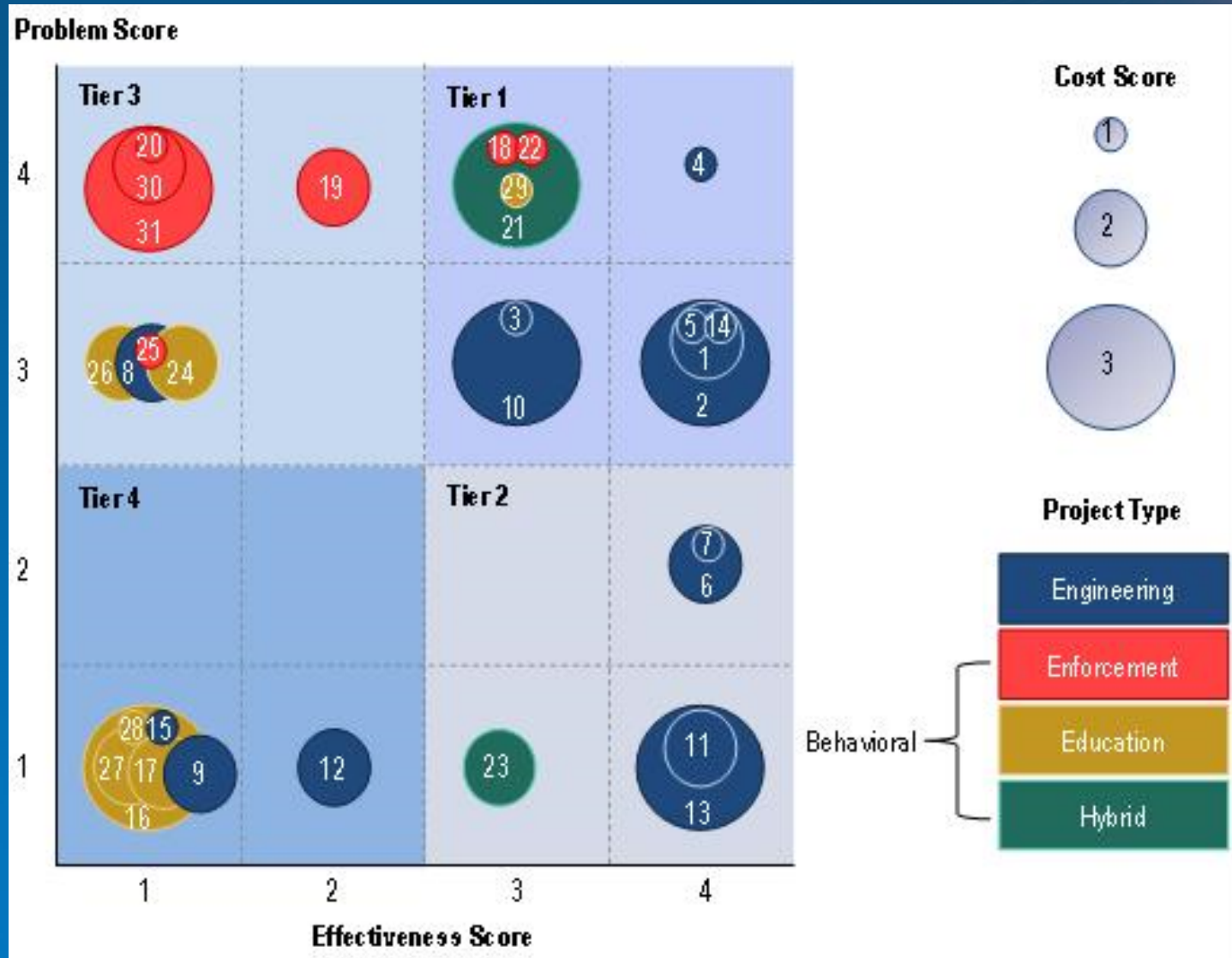


Cost Effectiveness of Behavioral Projects

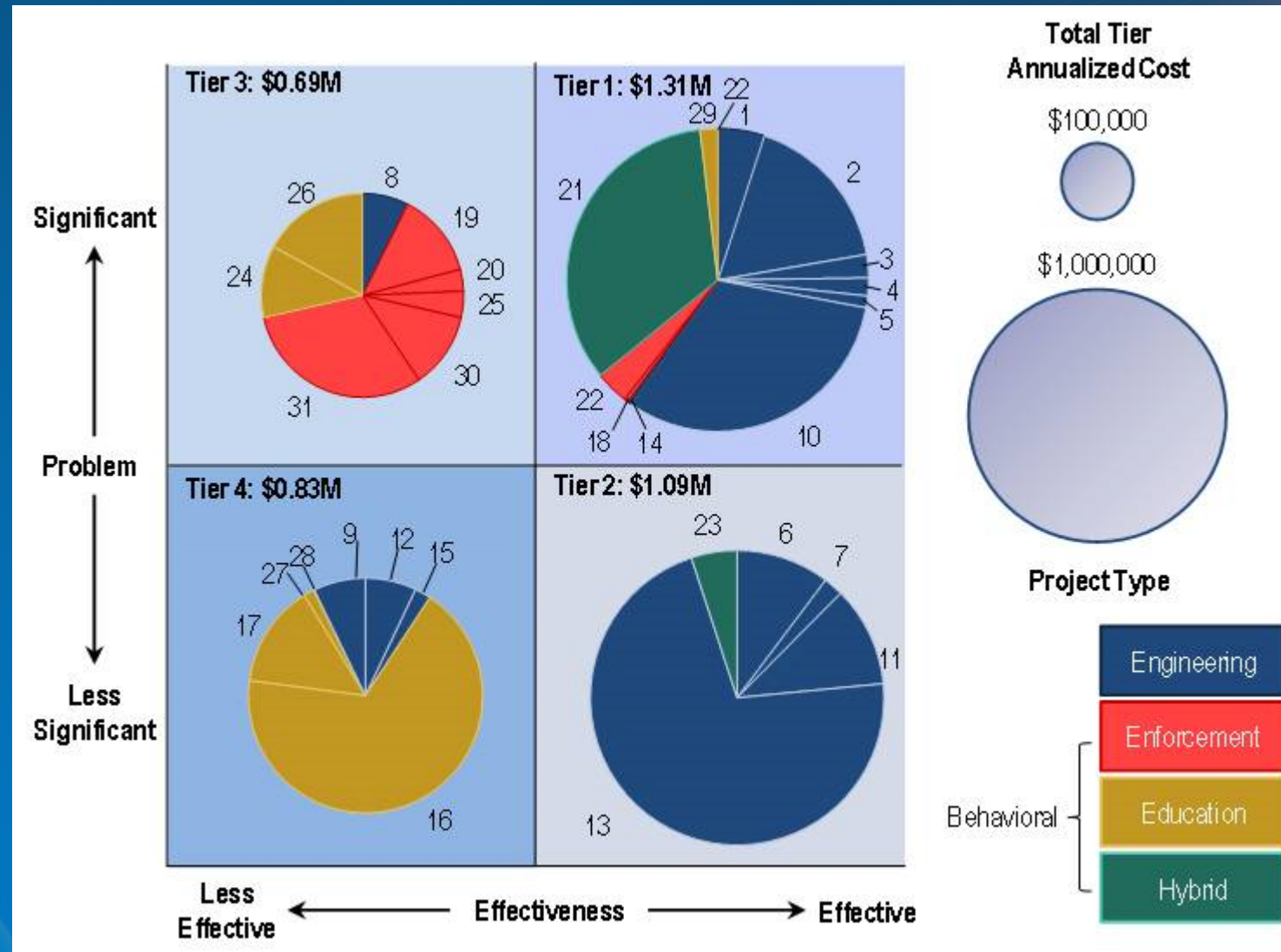
Project No.	Project Description	Effectiveness Score	Problem Score	Cost Score
21	BAT mobile unit program (check pts and outreach)	3	4	3
22	Mem units for monitoring high-risk DWI offenders	3	4	1
23	Underage alcohol prevention outreach and enforcement	3	1	2
24	Purchase motorcycles for training and expand motorcycle safety training facility	1	3	2
25	Conduct motorcycle safety check points	1	3	1
26	Improvement of driver education program implementation	1	3	2
27	Meeting room rental for young drivers safety conference	1	1	2
28	Fatal alcohol Goggles (for underage alcohol prevention outreach)	1	1	1
29	Hispanic driver safety outreach and child safety seat check	3	4	1



Cost Effectiveness of Engineering and Behavioral Projects with Prioritization Tiers



Cost Effectiveness of Engineering and Behavioral Projects with Tier Annualization Cost Project Type



Comparison of NCDOT Engineering Project Benefit-Cost Ratio with Prioritization Tier

Project No.	Project Description	Tier	NCDOT B/C Ratio
1	Raised median and pedestrian improvements	1	26.12
2	18.26 miles of single face guard rail	1	3.69
3	Directional crossover with median U-turn	1	4.28
4	Roundabout in-lieu of existing intersection	1	5.95
5	Left-turn lanes on all approaches and install a traffic signal	1	3.46
10	Add two-foot paved shoulders plus a minimum four-foot grass shoulders for 7.4 miles	1	3.26
14	Convert existing stop control intersection to signalized	1	3.93
6	Provide a continuous center left-turn lane	2	5.9
7	Left-turn lane and pavement friction treatment	2	14.54
11	Install shoulder guard rail	2	3.09
13	Install shoulder rumble strips (four shoulders total) for 21 miles	2	3.13
8	Widen for a third travel lane	3	12.38
12	Extend the acceleration ramp and install snow-plowable RPM	4	30.18
15	Realign routes for continuous movement	4	8.67
9	Install raised centerline pavement markers and upgrade existing signage	4	7.24

Opportunities with Sketch Method

- Comparison of different safety project types is possible
- Results help focus on the most cost effective strategies

Challenges with Sketch Method

- Some projects can't be scored
- Projects have multiple components
- Projects may not be well-defined
- Missing or questionable effectiveness information
- Uncertainty regarding duration of effectiveness

Additional Research

- More effectiveness information for a wider range of project types, including combinations of projects, including:
 - » Duration of effectiveness
 - » Geographic area of effectiveness
 - » Funding required to produce results
- Consistent definitions of effectiveness
- Uniform cost and useful life assumptions
- Better quality crash data