Capital Area Metropolitan Planning Organization

Blueprint for Safety

Recommended Revisions and Results of Roadway Prioritization Tool Enhancements

High Street Consulting Group

VHB

CAMPO ROADWAY PRIORITIZATION TOOL – SAFETY CRITERIA ENHANCEMENTS MEMO

This memo describes the enhancements made to the Roadway Prioritization Tool (RPT) as part of the current *Blueprint for Safety* plan. There are several plan components that can be leveraged to update the RPT's underlying criteria. The improvements listed below enhance the safety component of the Metropolitan Transportation Plan (MTP) prioritization process. Many high ranking MTP projects are mobility projects with safety enhancements, but safety-specific projects are often ranked low in previous versions of the RPT. For the purposes of the RPT, a "safety-specific project" is one that has a primary or secondary purpose of reducing fatal and serious injury crashes - as noted in either by the project type or project description. The projects evaluated by the RPT do not necessarily meet the definition of a "safety project" per Highway Safety Improvement Program (HSIP) criteria.

Three goals were identified to be accomplished in enhancing the safety criteria:

Goals:

1. Increase the safety score for safety-specific projects
2. Maximize excess crashes in prioritized projects
3. Improve scoring for multi-modal/bike/ped/VMT-reducing projects

To improve safety scoring reliability, we propose an expanded list of improvement types, use of safety risk in scoring, and better assignment of crashes. A brief description of the three enhancements identified in coordination between CAMPO and the Blueprint for Safety team are as follows:

1. Expand to include all Specific Improvement Types

Possible Enhancement	Requisite Actions to Accomplish
Utilize the full list of NCDOT Specific Improvement Types (SIT) and associated Safety Benefit Factors (SBF)	NCDOT has a total of 40 SITs to utilize, while the existing RPT only utilizes 27. This would involve incorporating the full list of highway project SITs, as well as creating a systemic check of assignments of projects to SITs.

In practice, this updates the Data section of the safety scoring criteria, expanding the number of SITs by 13 and assigning all SITs to projects based on project descriptions and roadway attributes. See the Figure 1 below for the updated flowchart methodology.

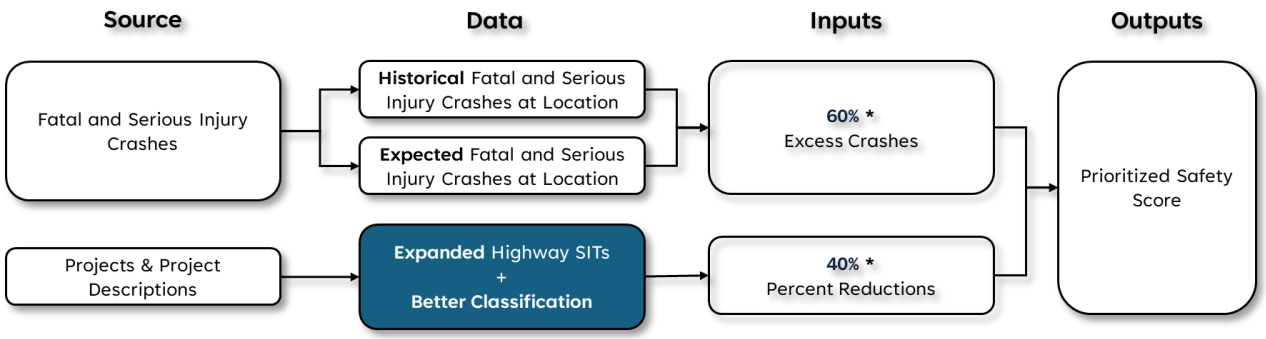

Figure 1: Safety Score Process - SIT

The current prioritization tool utilizes 27 SITs and averages project benefits based on a crosstab of SIT Safety Benefit Factors (SBFs) to the "Improvement Type" found in each MTP Project. SIT averaging occasionally lowers the impact on some projects and raises the impact on others. Table 1 below shows the 27 SITs used in the previous version of the RPT.

Table 1: Original SITs Used

Highway Specific Improvement Type	SBF
1 - Widen Existing Roadway	0%
1A - Widen Existing Roadway - Add lane to Freeway	10%
1B - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided - Rural	55%
1C - Widen Existing Roadway - Install two-way left turn lane on a 2 lane roadway	20%
1D - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided Superstreet with Partial Control of Access - Urban	15%
1E - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided with Partial Control of Access - Urban	10%
1F - Widen Existing Roadway - Widen 4 lane divided roadway to 6 lane divided - Urban	15%
4 - Upgrade Arterial to Superstreet	35%
5 - Construct Roadway on New Location	0%
5A - Construct Roadway on New Location - Freeway Bypass	10%
5B - Construct Roadway on New Location - Superstreet Bypass	5%
5C - Construct Roadway on New Location - Multi-Lane Highway Bypass	5%
6A - Construct Roadway on New Location - Freeway Bypass	10%
6B - Construct Roadway on New Location - Superstreet Bypass	5%
6C - Construct Roadway on New Location - Multi-Lane Highway Bypass	5%
7 - Upgrade At-grade Intersection to Interchange or Grade Separation	40%
8 - Improve Interchange	10%
9 - Convert Grade Separation to Interchange	0%
10 - Improve Intersection	25%
11 - Access Management	25%
13 - Citywide Signal System	5%
14 - Closed Loop Signal System	15%
16 - Modernize Roadway	20%
18 - Widen Existing Local (Non-State) Roadway	0%
20 - Convert Grade Separation to Interchange to Relieve Existing Congested Interchange	0%
21 - Realign Multiple Intersections	15%
23 - Construct Grade Separation at Highway / Railroad Crossing	90%
26 - Upgrade Roadway	20%

The updated RPT includes 14 additional SITs shown in Table 2. 13 of these improvements come from the remaining unused SITs, while the final 41st SIT, "27 – Bike / Pedestrian Facilities," was developed by selecting applicable pedestrian and bike countermeasures from the Crash

Modification Factor (CMF) Clearinghouse and averaging the associated Crash Reduction Factors (CRFs). CRF is a metric that is similar to SBF.[1] The countermeasures used are shown in Table 3.

[1] The "27 – Bike / Pedestrian Facilities" SIT is not the same as the Bicycle and Pedestrian SIT used by NCDOT SPOT as project types for independent bicycle and pedestrian projects. The SIT referenced in this memo, for the purposes of the RPT, are features for walking or bicycling to be included in a highway project (often referred to as Complete Streets). Furthermore, the CMFs in the CMF Clearinghouse do not necessarily match that of the NCDOT Project Development CRF Information workbook.

Table 2: 14 Additional SITs Added

Highway Specific Improvement Type	SBF
1D-1E - Created as mix of 1D and 1E	13%
2 - Upgrade Arterial to Freeway/Expressway	40%
3 - Upgrade Expressway to Freeway	25%
6 - Widen Existing Roadway and Construct Part on New Location	0%
10 - Improve Intersection	25%
10A - Improve Intersection - Roundabout	40%
12 - Ramp Metering	5%
15 - Install Cameras and DMS	0%
17 - Upgrade Freeway to Interstate Standards	10%
19 - Improve Intersection on Local (Non-State) Roadway	25%
22 - Construct Auxiliary Lanes or Other Operational Improvements	10%
24 - Implement Road Diet to Improve Safety	25%
25 - Improve Multiple Intersections along Corridor	25%
27 – Bike / Pedestrian Facilities	**47%**

Table 3: CMFs used to develop the "27 – Bike / Pedestrian Facilities" SIT

CMF ID	Name	Crash Type	Crash Reduction Factor (CRF)
11246	Install Sidewalk	Vehicle/Pedestrian	40.2
9240	Install Sidewalk	Vehicle/Bicycle	59
11555	Install Bike Lanes	All	42.9
Average CRF			**47%**

After introducing the 14 new SITs, the project team performed a tiered approach to assigning SITs to projects. The intent was to systemically check the project details and roadway attributes to determine which SIT is applicable. If there was insufficient project information, SBFs are averaged across the multiple SITs that match the list of 13 "Improvement Types" in Figure 2.

Figure 2: 13 Proposed Improvement Types

Tier 1

The project problem statement, improvement type, urban/rural classification, existing lanes, proposed lanes, existing facility, and proposed facility are used to match the project to the relevant SIT. Table 4 shows example criteria used for different SITs. See Table 11 in Appendix for the full table.

Table 4: Example Criteria for SIT to Project Matching

Specific Improvement Type (SIT)	Problem Statement Key Word	Urban/ Rural	FFC	Existing Facility Type	Future Facility Type	Existing Lanes	Proposed Lanes
1B - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided - Rural		Rural				2	4
1D - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided Superstreet with Partial Control of Access - Urban		Urban			Boulevard	2	4
2 - Upgrade Arterial to Freeway/Expressway				Not Freeway or Expressway	Freeway or Expressway		
9 - Convert Grade Separation to Interchange				Grade Separation	Interchange		
10A - Improve Intersection - Roundabout	Roundabout						
27 – Bike/ Pedestrian Facilities	Bike or bic*or cyc* or multi* or pedestrian or sidewalk or trail*		Not Interstate, Urban Interstate, Rural Interstate, Urban Freeway/Expressway, N/A - Interchange/GS				

Tier 2

If no matching SITs were available based on the Tier 1 query, the average SBF of all projects for the relevant improvement type was used. Figure 3 shows an example of the SBF "Tier 1" and "Tier 2" calculation approach for a widening project.

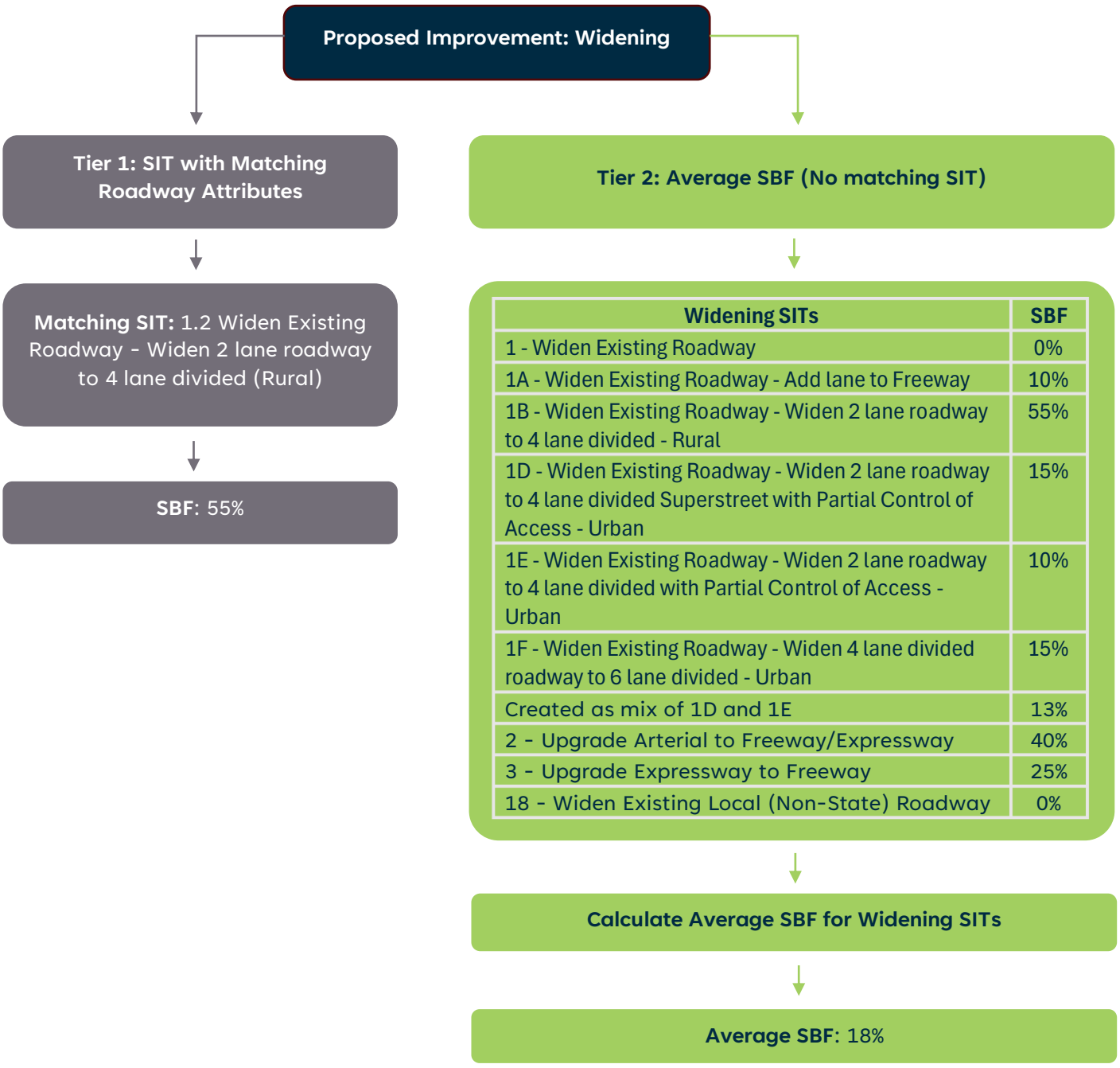

Figure 3: Example SBF Calculation Approach

2. Implement "Likelihood" from the Blueprint for Safety

Possible Enhancement	Requisite Actions to Accomplish
Add a criterion to reflect the "likelihood" index developed as part of the *Blueprint for Safety* plan.	This involved adding a third criterion to the safety score at a weight identified by CAMPO staff. The 'likelihood' index better captures the potential risk at a site location. This index is based on a series of statistical models developed during the Blueprint for Safety plan development process. The updated index factors in county, urban/rural classification, AADT, number of lanes, proximity to schools, and population/employment density to calculate the likelihood that a Lane Departure, Speeding, Bike, or Pedestrian fatal (K), suspected serious injury (A), or minor injury (B) crash might occur based on the characteristics of the segment or intersection. This index does not consider if a crash has previously occurred at a location, and therefore is a complementary process to expected fatal and serious injury crashes. The likelihoods were developed using the MTP Links network and were assigned to all links (non-interstate links in the case of bicycle and pedestrian likelihoods) on the network. However, a roadway project can span more than one MTP link. Thus, a length weighted average calculation was used to combine the likelihoods from multiple links. If a project has a bike or pedestrian related SIT, shown in Table 5, the max Bike or Pedestrian likelihood value is used in the safety score. Otherwise, the max likelihood value is used. An example is shown in Figure 4.

Table 5: Bike or Pedestrian Related SITs

ID	Highway Specific Improvement Type (SIT)
10	Improve Intersection
10A	Improve Intersection - Roundabout
11	Access Management
16	Modernize Roadway
19	Improve Intersection on Local (Non-State) Roadway
24	Implement Road Diet to Improve Safety
25	Improve Multiple Intersections along Corridor
26	Upgrade Roadway
27	Bike/ Pedestrian Facilities

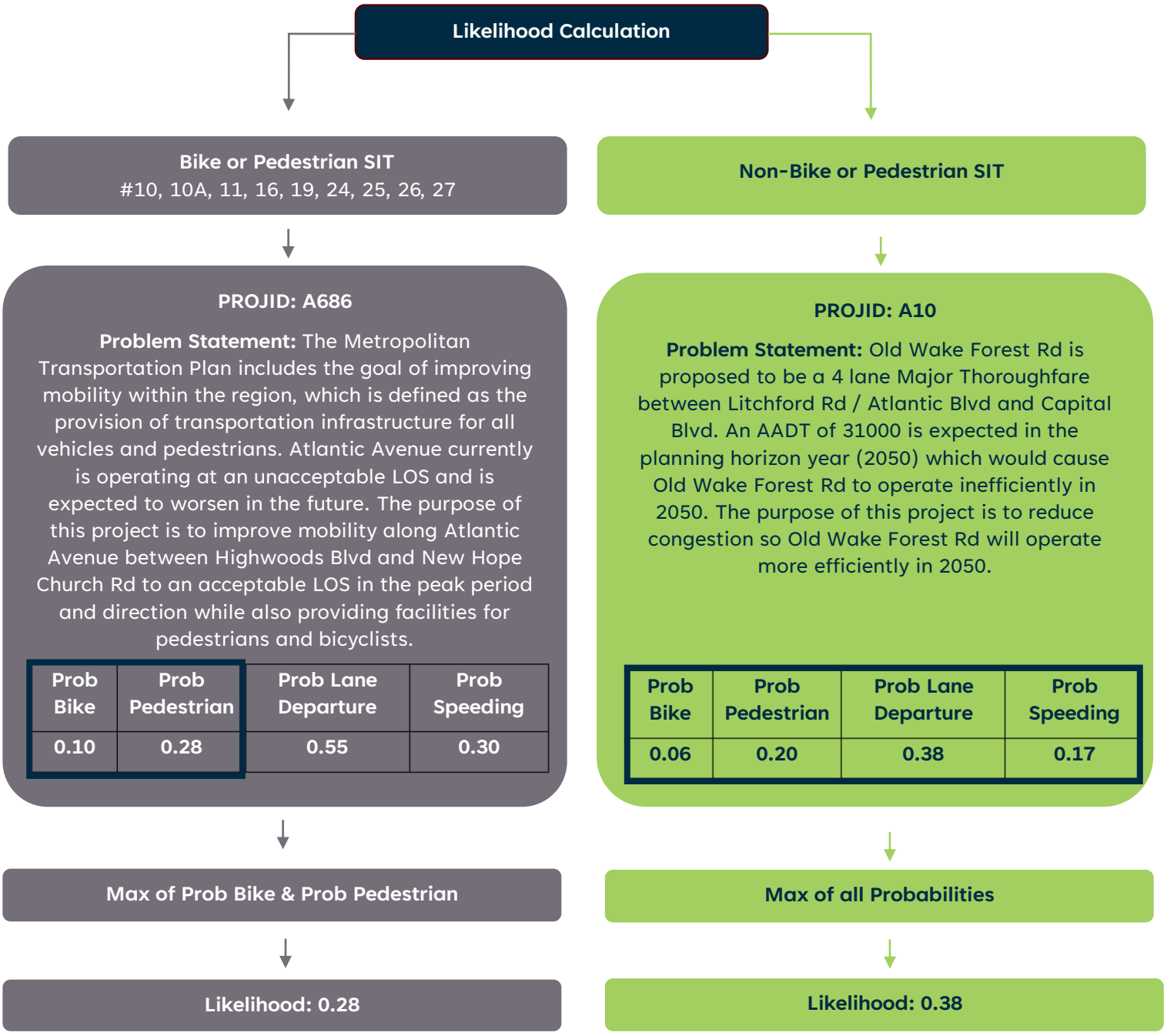

Figure 4: Example of Likelihood Calculation Methodology

Several likelihood weighing options were tested to find an optimal weighting factor to balance likelihood with the number of excess crashes within the top projects. The likelihood weight of 20% was chosen due to capturing the most excess crashes when the top 100 projects as shown in Table 6.

Table 6: Excess Crashes for the Top 100 Projects by Likelihood Weight

	20%	30%	40%
Boulevard	107	46	52
Grade Separation		1	1
Major Thoroughfare	55	32	32
Minor Thoroughfare	338	320	320

The updated script now calculates risk from MTP links directly using the following attributes.

- AADT
- Route Class
- Number of Lanes
- Demographic, employment, socioeconomic characteristics at the Census Block Group level
- Relevant County
- Segment Length

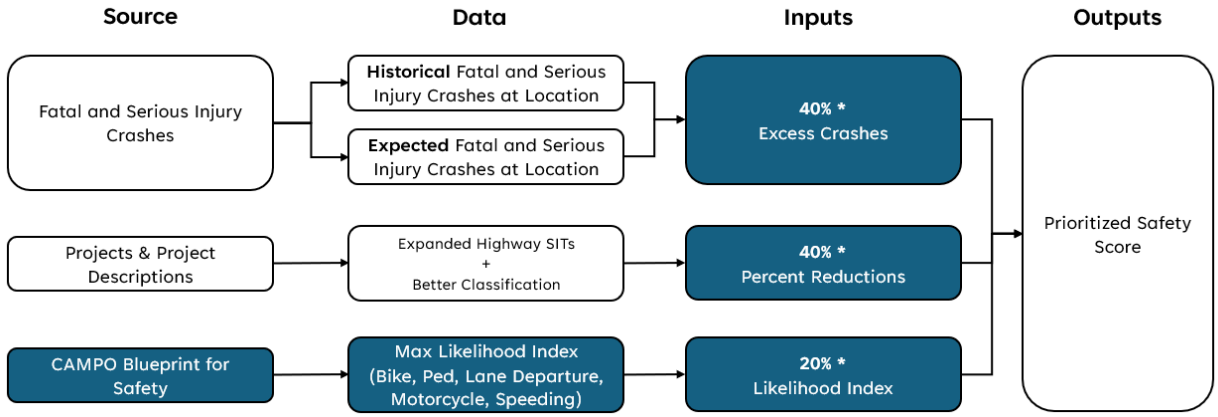

Figure 5: Safety Score Process – Likelihood

New Weighted Metric:

Safety Score =	Need 40% * (Historically observed fatal and serious injury crashes - *Expected* fatal and serious injury crashes by average crashes per mile of facility type)	+	Impact 40% * (Safety Benefit Factor)	+	Importance **20% *** (Likelihood Index: Probability of Bike, Pedestrian, Lane Departure, or Speeding Crashes)

3. Excluding inaccessible crash locations

Possible Enhancement	Requisite Actions to Accomplish
This is an issue where the current buffering routine does not account for Triangle Regional Model (TRM) connectivity when determining the number of crashes that fall within any given project corridor. An example of this would be a crash occurring along a bi-directional state road having a grade separation with a freeway. Any crashes along this limited-access facility that fall within the buffer of the state road are currently being included in this scoring criteria thereby influencing the project score.	Selected Approach: Crashes are snapped then joined to the nearest segment. If the crash was more than 150 feet from the segment, it is filtered out, as shown in Figure 7.

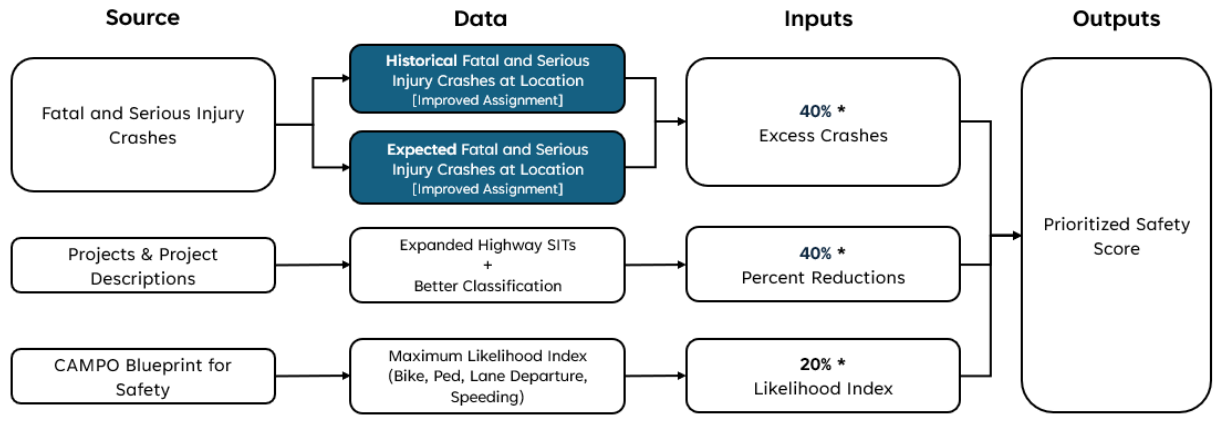

Figure 6: Safety Score Process – Crash Spatial Join

	Need		Impact		Likelihood
Safety Score =	**40% *** (*Historically observed* fatal and serious injury crashes - *Expected* fatal and serious injury crashes by average crashes per mile of facility type)	+	40% * (Safety Benefit Factor)	+	20% * (Likelihood Index: Probability of Bike, Pedestrian, Lane Departure, Motorcycle, or Speeding Crashes)

The new crash joining method is illustrated in Figure 7 where the crash is first snapped to the nearest road segment and filtered out if the distance from the crash to the segment was more than 150 feet.

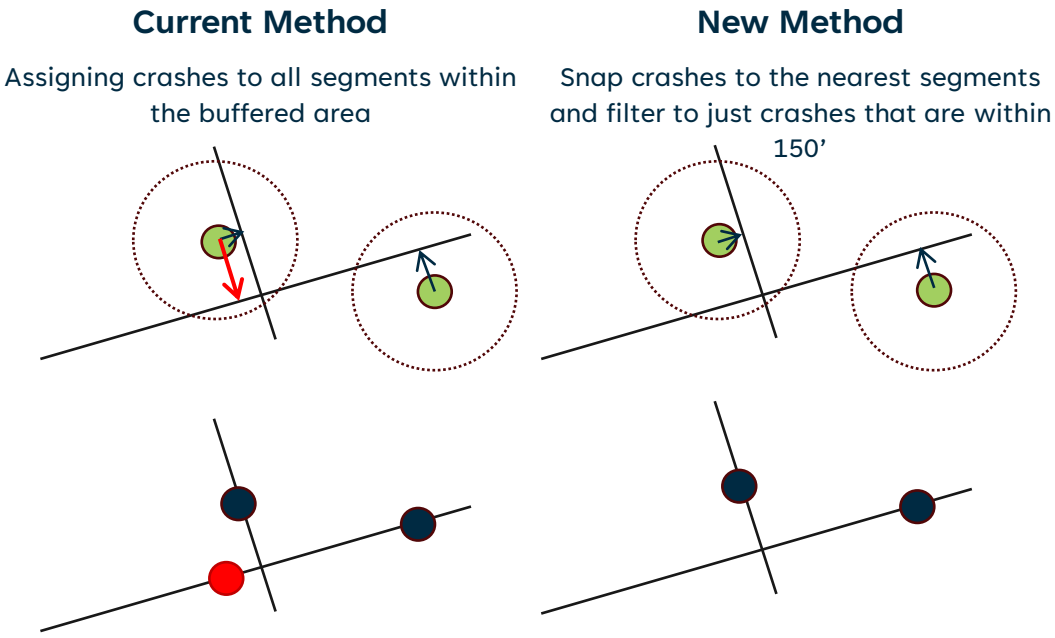

*Figure 7: Explanation of Updated Crash Joining with the removed join and crash in **Red***

A Topologic Validation approach was investigated but not implemented. Instead of a straight-line buffer around a corridor the analysis would be limited to links that fall within the distance specified but only along the topologically valid parts of the network. The tool needed for this is Service Area Analysis Layer in the ArcGIS Pro Network Analyst toolbox and a similar tool exists in R under the OSRM package (Iso-distance function). This was not used because the tool currently joins points to segments, instead of the current approach of segments to segments.

Result of Proposed Enhancements

Enhancements #1 (SBF & Applicable Improvement Expansion), #2 (Likelihood Implementation), and #3 (Improved Crash Joining) were implemented and the updated scores are shown in the following section. Figure 8 shows the new prioritized safety score methodology and weighting with the added likelihood index.

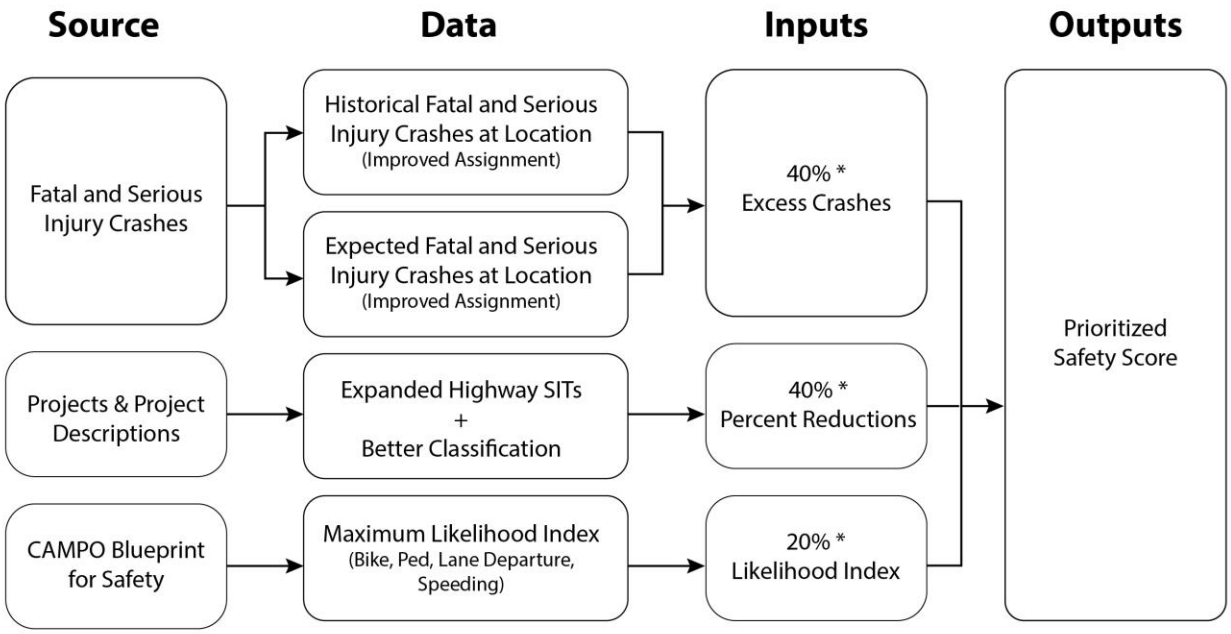

Figure 8: Updated Prioritization Tool Safety Scoring Flowchart

With these improvements in the methodology of the "Prioritized Safety Score," the project team was able to **increase the safety score for 689 projects**. As a result, 548 of these projects saw a higher overall score. This increased the rank for 409 of those projects and prioritized projects with a safety need or provide some benefit to vulnerable road users such as bicyclists and pedestrians.

However, the majority of the MTP projects are still car-centric with very few projects that are targeted specifically at safety or bike and pedestrian improvements. Most projects had "Problem Statements" that were focused on another issue with tangential bike and pedestrian improvements. "Providing facilities for pedestrians and bicyclists," was typically added at the end of the "Problem Statement" for these projects. Of the 900 roadway projects, there are five that specifically mention crashes in their "Problem Statement," and of that, one specifically states they hope to make improvements to increase the safety for cyclists and pedestrians.

Overall, our enhancements help prioritize true safety and bike/pedestrian improvements projects. The updated enhancements improved the safety score, overall score, and rank for these projects.

Script Changes

The following edits detail the changes to each script for the RPT.

Adjusted: master2.R

- Set up an RStudio script outline and headings for organization
- Condensed and streamlined the library installation
- Moved the Safety Criteria Weighting to this script, rather than within the safety criteria script.

New: safety_likelihood_calculation.R

- Calculated a likelihood index – This script applies the statistical models developed during the Blueprint for Safety plan to segments. This calculates a likelihood index or "score" for Lane Departure, Speed, Bicycle, and Pedestrian crashes. To calculate this score, segments need to contain the following fields and relevant data:
    - County in which the segment is located
    - Route Class, including:
        - Interstates
        - US Routes
        - NC Routes
        - Secondary Routes
        - Other
    - AADT
    - Number of Lanes
    - CDC Social Vulnerability Index (SVI)
    - Census Block Group-Based Data:
        - Block group area (sq. Mi.)
        - Total Population
        - Total Employment
        - Proportion of Zero Vehicle Households
    - Context Classification (as noted in NCHRP Research Report 1022)
        - Urban Core
        - Urban
        - Suburban
        - Rural Town
    - Rural
    - Proximity to a transit stop (within 100 Ft.)
    - Proximity to a school or university (within qtr. Mi.)

Adjusted: safety_criteria.R

- Enhancement #1- Expanded the SITs and applicable SBFs. Added columns (Existing facility type, proposed facility type, existing lanes, proposed lanes, project statement, tier, SIT, SBF) to the final spreadsheet output of safety scores
- Enhancement #2- Used a length weighted average to calculate the likelihood index for each project. Took the maximum likelihood value between Bike and Pedestrian for SITs 10, 10A, 11, 16, 19, 24, 25, and 26, otherwise the overall maximum likelihood of Lane Departure, Speeding, Bike and Pedestrian was used.
- Enhancement #3- Crash snapping to project geometry within 150 feet. Used this approach to calculate the crash count and expected crashes.

Enhancement Impact on Safety Scores

The average safety score increased for 5 existing facility types and decreased for expressways where there are less likely to be bike and ped projects. Although freeways did see a slight increase, that may be due to the large number of excess crashes, 178.

Table 7: Average Safety Scores and Total Number of Excess Crashes per Existing Facility Type

Facility Type Existing	Average Safety Score		Excess Crashes
	Previous	New	
At-Grade Intersection	59	41	0
Boulevard	28	31	95
Expressway	27	18	0
Freeway	29	32	178
Grade Separation	30	14	0
Interchange	33	19	18
Major Thoroughfare	29	29	39
Minor Thoroughfare	26	32	120
Not Applicable	26	17	8
Not Available	19	34	0

Goal 1: Increase the Safety Score for True Safety Projects

Of the 6 roadway projects that specifically mention focus on excess crashes, three projects successfully saw an increase in their safety score with the enhancements due to better SBF or inclusion of likelihood. While there may be excess crashes for these projects, there are no excess fatal or serious injury crashes. However, three projects saw a decrease in safety score. Their newly assigned SBF value was lower than before. Project A782 is summarized to illustrate how the enhancements altered project scoring.

Table 8: Safety Scores - Crash Specific Projects

PROJID	Proposed Improvement	Fatal and Serious Injury Count	Excess KA Crashes	SBF	Likelihood	Likelihood Value	Safety Score	
							Previous	Current
A782	TSM	5	-	0.47	Pedestrian	0.18	20.86	37.95
A783	Access Management	4	-	0.25	Lane Departure	0.53	49.45	29.31
A808	New Location	-	-	0.05	Lane Departure	0.73	18.25	19.00
A810	TSM	2	-	0.14	Lane Departure	0.49	30.78	20.48
A811	TSM	-	-	0.14	Lane Departure	0.22	29.76	14.89
Grnv96	Modernization	2	-	0.15	Lane Departure	0.52	18.97	22.01

Project A782: TSM Knightdale Boulevard Safety Project

Problem Statement: *Knightdale Boulevard is proposed to be a 4 lane Major Thoroughfare between N. First Ave. and I87. A crash analysis indicated a crash rate of 52.8 for the 3 year analysis period. This crash rate exceeds statewide and critical crash rates. The project intends to enhance safety along Knightdale Boulevard by reducing the number of crashes, as well as providing safer passage for cyclists and pedestrians.*

This project, which emphasizes multimodal safety, experienced a 17% increase in its overall safety score. The improvement was largely due to the more accurate assignment of SITs and the inclusion of crash likelihood in the scoring process. Although the project identified a high number of crashes, its analysis included crashes of all severities. In contrast, the RPT evaluates historic crash performance based solely on fatal and serious injury crashes, which may lead to different prioritization outcomes than a broader total crash focus.

Safety Metric	Original Value	New Value
Excess KA Crashes	0	0
Likelihood	NA	0.18
SIT	10	47

Area	Overall Scores	
	Original	New
Safety	21%	38%
Connectivity	0%	
Congestion & Reliability	27%	
Economic	18%	
Multimodal	42%	
Equity	44%	
Environmental	48%	
Condition	0%	
Overall Score	26%	
Overall Rank	504	180

Goal 2: Maximize Excess Crashes

The new top 100 projects more closely align with facility types that have the highest excess crashes. Minor Thoroughfares have high excess crashes for non-access-controlled roads (120), with 2025 projects increasing significantly (89 vs. 27 in 2023).

Table 9: Count of Top 100 Projects by Facility Type

Facility Type	Number of Projects (Old Criteria)	Number of Projects (New Criteria)	Number of Excess Crashes
Boulevard	6	3	95
Freeway	10	4	178
Minor Thoroughfare	27	89	120
Major Thoroughfare	14	4	39
Not Applicable	30	0	8
At-Grade Intersection	1	0	0
Interchange	8	0	18
Grade Separation	3	0	0
Expressway	1	0	0

Additionally, project F41 now ranks second on safety scores compared to first due to a better assignment of fatal and serious injury crashes. The safety score decreased by 6 points. Project A90c is now ranked first. (4 lane Boulevard between US 401 Rolesville Bypass and Flat Rock Church Rd)

Table 10: Top 3 Projects using new criteria adjustments

Rank	PROJID	Problem Statement	Excess Fatal & Serious Injury Crashes	Likelihood Factor	Safety Benefit Factor
1	A90c	US 401 is proposed to be a 4 lane Boulevard between US 401 Rolesville Bypass and Flat Rock Church Rd.	6	0.65	0.55
2	F41	Improve mobility along I-40 Managed Lanes between Wade Avenue and Johnston County to an acceptable LOS in the peak period and direction while also providing facilities for pedestrians and bicyclists.	29	0.51	0.18
3	A445a	NC 50 is proposed to be a 4 lane Boulevard between NC 98 and Beaver Creek Rec.	3	0.75	0.55

Goal 3: "VMT Reducing" Project Impacts

The new criteria adjustments showed that **54** roadway projects that specifically mention "sustainable transportation" or "multi-modal" **saw an increase in their safety score**. **80** roadway projects that do not mention "mobility" *and* do not mention "congestion" **saw an increase in their safety score**.

For example, Project Jhns13a: Multi-modal access, had an overall safety score increase by 24% due to better SIT assignment and likelihood inclusion. While the excess crashes decreased due to better assignment of crashes, overall, the project jumped 170 spots.

> ***Project Jhns13a: Multi-modal access Problem Statement:*** *The Metropolitan Transportation Plan identifies the areas adjacent to NC 42 between US 70 BUS and Ranch Road as not currently served by any form of transportation infrastructure. Future land use changes for this area will require accessibility by motorized vehicles. Therefore, the desire exists to provide transportation access. The purpose of this project is to provide new multi-modal access to land adjacent to this corridor.*

Safety Metric	Original Value	New Value
Excess KA Crashes	0.63	0
Likelihood	NA	0.41
SIT	0	47

Area	Overall Scores	
	Original	New
Safety	19%	43%
Connectivity	0%	
Congestion & Reliability	27%	
Economic	51%	
Multimodal	26%	
Equity	10%	
Environmental	55%	
Condition	0%	
Overall Score	31%	
Overall Rank	241	71

While Bike/Ped-specific projects were scarce in the MTP, one particularly Bike/Ped focused project's overall safety score increased by 13% due to better SIT assignment and likelihood inclusion. While the excess crashes decreased due to better assignment of crashes, overall, the project jumped 210 spots.

> ***Project A684: Two-way road with Bike & Pedestrian Facilities Problem Statement:*** *The Metropolitan Transportation Plan includes the goal of improving mobility within the region, which is defined as the provision of transportation infrastructure for all vehicles and pedestrians. The purpose of this project is to improve mobility by converting Blount and Person Streets to 2-way operations between Hoke Street and Sasser Street while also providing facilities for pedestrians and bicyclists.*

Safety Metric	Original Value	New Value
Excess KA Crashes	13.19	11.00
Likelihood	NA	0.21
SIT	10	47

Area	Overall Scores	
	Original	New
Safety	39%	52%
Connectivity	0%	
Congestion & Reliability	27%	
Economic	18%	
Multimodal	6%	
Equity	47%	
Environmental	57%	
Condition	0%	
Overall Score	27%	
Overall Rank	422	212

Appendix A: Using the Prioritization Tool for Safety Scoping

[Not Currently Scoped]

This appendix describes potential enhancements to the RPT (i.e., a separate safety-specific component) to apply the Blueprint for Safety recommendations. This builds upon the project evaluation function currently in the RPT and would support diagnosis of safety issues and countermeasure selection at specific locations.

Per discussion with CAMPO at a meeting on October 9, 2024, these enhancements can support sub-area and corridor studies and assist project scoping at locations of greatest safety need prior to MTP project evaluation. These enhancements have not been implemented.

1. Alternative Countermeasure Analysis

Possible Enhancement	Requisite Actions to Accomplish
The potential for the tool to provide alternative scenarios of using different countermeasures or NCDOT SITs.	The purpose of this enhancement is to help tailor countermeasures to the safety need of a location (e.g., lane departure, intersections, or pedestrian safety) and consider different impacts of countermeasures. The tool can be updated to output either: 1. The best combination of countermeasures for the largest reduction in crashes relative to the crash types that are flagged as part of the Blueprint for Safety screening. The safety plan produced a linear road and intersection polygon dataset that can be queried. 2. High/Med/Low categories of combination of countermeasures based on funding. 3. Countermeasures that are applicable to the crashes based on crash type. This would require updating the script to relate crashes to specific types based on other attributes of the crash and updating the script to choose benefits based on North Carolina Project Development CRF Information[2] and associated CMFs. SITs for independent bicycle/pedestrian improvements (i.e., not part of a highway project) will also need to be developed and scored by the RPT to expand the set of MTP projects eligible for scoring in the NCDOT Strategic Transportation Investments (STI) prioritization (SPOT) process.

New Metrics:

2 https://connect.ncdot.gov/resources/safety/TrafficSafetyResources/NCDOT%20CRF%20Update.pdf

Safety Need =	Anticipated KAB crashes (per crash type) based on probability scores and study period duration		
Safety Impact =	Anticipated KAB Crashes by Applicable Crash Type	*	Crash Modification Factor or Expanded Safety Benefit Factors

2. Adjust Facility Characteristics

Possible Enhancement	Requisite Actions to Accomplish
The potential to allow users to dynamically adjust condition inputs (roadway characteristics) for a specific location; • Volume (AADT) • Functional Classification • Observed or Posted Speed • Facility Information (lanes, median, etc.)	The script can ask users if they would like to update the roadway/intersection characteristics and an output of roadway/intersections with facility characteristics are provided to be edited. This can produce changes to the probability of certain crashes to help users understand safety impacts of planning/scenario decisions.

3. Develop Safety Improvements Based on Context and Site Characteristics

Possible Enhancement	Requisite Actions to Accomplish
The potential to scope and develop projects tailored to specific site-level conditions and safety need (see Enhancement #1 and #2).	Enhancements #1 and #2 would present countermeasures that are relevant to safety need (e.g., Lane Departure or Intersections) and allow the user to review/update project site characteristics. This enhancement would curate the list of countermeasures potentially suitable for the site conditions for discussion with NCDOT and project stakeholders.

4. Combining Safety Benefits

Possible Enhancement	Requisite Actions to Accomplish
The potential to combine safety benefits across (packages of) difference safety needs and countermeasures. Countermeasures would be categorized (very generally) to target the following crash/facility types: 1. Bike 2. Pedestrian 3. Intersection (total and bike/ped crashes) 4. Lane departure	This can be possible by updating the SIT table with generalized improvements based on NCDOT countermeasures (e.g., North Carolina Project Development CRF Information) and crash reduction factors. The approach to enhancement #4 should be compatible with enhancement #1; the countermeasures and benefits used in both enhancements should be coordinated. The tool currently only applies one SIT per project/segment/intersection so we would use the highest applicable CRFs (i.e., the greatest estimated benefit) of each applied countermeasure if addressing the same crash type. When countermeasures are applied to different crash types, the benefits would be applied directly to each applicable crash type. The estimated

	reduction in crashes would be the sum of the benefits of both countermeasures. **i.e.** Two improvements addressing the same crash type, one with 40% CRF and one with 60% CRF: ***Total Reduction =*** ***Crash Type A Estimated KAB Crashes * [1 - 60%]*** **i.e.** Two improvements addressing different crash types, a countermeasure for crash type A has a 40% CRF and a countermeasure for crash type B has a 80% CRF: ***Total Reduction =*** ***Crash Type A Estimated KAB Crashes * (1 - 40%) +*** ***Crash Type B Estimated KAB Crashes * (1 - 80%)*** As an additional component of the enhancement, the probability scores from the Blueprint for Safety screening would need to be adapted to a general KAB crash frequency. This can be done for a defined study period for a corridor or sub-area study.

Appendix B: Complete List of SIT Assignment Criteria

Due to limitations in the roadway characteristics available in the data and the ambiguity in the SIT description, not all SITs were matched using roadway characteristics. However, all SITs were used in the calculated average SBF used in the "Tier 2" approach if no matching SIT was found through matching the roadway characteristics, "Tier 1" approach.

Table 11: Criteria for all SITs

Highway Specific Improvement Type (SIT)	Problem Statement Key Word	Urban/ Rural	FFC	Existing Facility Type	Future Facility Type	Existing Lanes	Proposed Lanes	Applicable Proposed Improvement
1 - Widen Existing Roadway								Widening
1A - Widen Existing Roadway - Add lane to Freeway				Freeway			`+1	Widening
1B - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided - Rural		Rural				2	4	Widening
1C - Widen Existing Roadway - Install two-way left turn lane on a two lane roadway								Center Turn Lane
1D - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided Superstreet with Partial Control of Access - Urban		Urban			Boulevard	2	4	Widening
1E - Widen Existing Roadway - Widen 2 lane roadway to 4 lane divided with Partial Control of Access - Urban		Urban				2	4	Widening
1F - Widen Existing Roadway - Widen 4 lane divided roadway to 6 lane divided - Urban		Urban				4	6	Widening
Created as mix of 1D and 1E								Widening

Highway Specific Improvement Type (SIT)	Problem Statement Key Word	Urban/ Rural	FFC	Existing Facility Type	Future Facility Type	Existing Lanes	Proposed Lanes	Applicable Proposed Improvement
2 - Upgrade Arterial to Freeway/Expressway				!Freeway, Expressway	Freeway, Expressway			Widening
3 - Upgrade Expressway to Freeway				Expressway	Freeway			Widening
4 - Upgrade Arterial to Superstreet								Superstreet
5 - Construct Roadway on New Location								New Location
5A - Construct Roadway on New Location - Freeway Bypass								New Location
5B - Construct Roadway on New Location - Superstreet Bypass								New Location
5C - Construct Roadway on New Location - Multi-Lane Highway Bypass								New Location
6 - Widen Existing Roadway and Construct Part on New Location								New Location
6A - Construct Roadway on New Location - Freeway Bypass								New Location
6B - Construct Roadway on New Location - Superstreet Bypass								New Location
6C - Construct Roadway on New Location - Multi-Lane Highway Bypass								New Location
7 - Upgrade At-grade Intersection to Interchange or Grade Separation				Not Grade Separation, Interchange	Grade Separation, Interchange			Grade Separation
8 - Improve Interchange				Interchange	Interchange			Interchange

Highway Specific Improvement Type (SIT)	Problem Statement Key Word	Urban/ Rural	FFC	Existing Facility Type	Future Facility Type	Existing Lanes	Proposed Lanes	Applicable Proposed Improvement
9 - Convert Grade Separation to Interchange				Grade Separation	Interchange			Interchange
10 - Improve Intersection								CFI
10A - Improve Intersection - Roundabout	Roundabout							CFI
11 - Access Management								Access Management
12 - Ramp Metering								TSM
13 - Citywide Signal System								TSM
14 - Closed Loop Signal System								TSM
15 - Install Cameras and DMS	Cameras							TSM
16 - Modernize Roadway								Modernization
17 - Upgrade Freeway to Interstate Standards				Freeway	Freeway			Modernization
18 - Widen Existing Local (Non-State) Roadway			Local or Urban Local					Widening
19 - Improve Intersection on Local (Non-State) Roadway								TSM
20 - Convert Grade Separation to Interchange to Relieve Existing Congested Interchange				Grade Separation	Interchange			Grade Separation
21 - Realign Multiple Intersections								Intersection Realignment

Highway Specific Improvement Type (SIT)	Problem Statement Key Word	Urban/ Rural	FFC	Existing Facility Type	Future Facility Type	Existing Lanes	Proposed Lanes	Applicable Proposed Improvement
22 - Construct Auxiliary Lanes or Other Operational Improvements								TSM
23 - Construct Grade Separation at Highway / Railroad Crossing								Grade Separation
24 - Implement Road Diet to Improve Safety	Road Diet							TSM
25 - Improve Multiple Intersections along Corridor								TSM
26 - Upgrade Roadway								Median
27 - Bike/ Pedestrian Facilities	Bike or bic*or cyc* or multi* or pedestrian or sidewalk or trail*		Not Interstate, Urban Interstate, Rural Interstate, Urban Freeway/Expressway, N/A - Interchange/GS					Varies