INCORPORATING RELIABILITY AND SAFETY INTO THE LONG-RANGE TRANSPORTATION PLAN: THE HILLSBOROUGH COUNTY EXPERIENCE

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ABSTRACT

The Hillsborough County Metropolitan Planning Organization (MPO) in Tampa, Florida identified the need to add both operations and safety projects to their Long-Range Transportation Plan (LRTP) update for the year 2040. However, the ability to forecast travel time reliability (a major outcome of operations projects) and safety conditions in conjunction with their travel demand model did not exist. This paper documents the technical development of a postprocessor to the travel demand model that performs these tasks. The reliability component was based on the method developed for the Strategic Highway Research Program 2 (SHRP 2) Project C11 and the safety component was based on methods in the Highway Safety Manual (HSM). Costs for operations and safety projects also were developed using data from the Federal Highway Administration’s TOPS-BC tool.

The methods were adapted to work with data available from the outputs of the travel demand forecasting model. As a result, the 2040 plan update now includes both operations and safety projects along with their estimated benefits and costs. This allows side-by-side comparison with benefits and costs of the traditional capacity, travel demand management, and transit projects that have dominated past plan updates. Once results for safety and operations projects were created, the Hillsborough MPO then used the resulting 2040 system performance forecasts as part of a public engagement program for the long-range transportation plan, asking citizens to choose their preferred level of investment and corresponding performance outcome.
INTRODUCTION
Transportation planning traditionally has considered capacity expansion, demand management, and transit improvements. However, planners are now being asked to take a more comprehensive view of transportation in their communities by including travel time reliability and safety projects. Reliability—and the operations projects that can improve it such as incident management, ramp metering, and advanced signal operations—is being recognized as a major component of how travelers experience the transportation system. Safety too is becoming a major emphasis for Metropolitan Planning Organizations (MPOs). However, the technical tools to assess reliability and safety at the planning level have been lacking.

In 2013, the Hillsborough County Metropolitan Planning Organization (MPO) in Tampa, Florida began working on the update to the Long-Range Transportation Plan (LRTP) called Imagine 2040 (1). The Tampa Bay Metropolitan Area is the 18th largest metropolitan statistical area in the country, and the second largest in Florida with over 2.8 million people in 2013, a 3.1 percent increase since 2010. At the heart of the Tampa Bay Metropolitan Area is Hillsborough County with over 1.2 million residents.

Like many MPOs, Hillsborough was faced with addressing multiple goal categories. These categories were:
- Preserve the system
- Reduce crashes and vulnerability
- Minimize traffic for drivers and shipper
- Provide real choices for drivers
- Grow economic activity centers

The MPO developed a comprehensive set of performance measures on which investments in the Plan would be assessed. However, only in some categories were tools and methods available for forecasting future performance. For example, roadway congestion is something metropolitan planners have been forecasting for a long time. But what about safety and reliability? What should you invest in, if the goal is to bring down the crash rate? And how much money will make a difference?

At the same time the MPO was facing these issues, the Florida Department of Transportation (FDOT) was engaged in in testing and promoting products developed under the Strategic Highway Research Program 2 (SHRP 2) that dealt with reliability prediction and incorporating operations into the planning process (2). Subsequently, the MPO became one of the sites for the FDOT SHRP 2 implementation effort. This was a chance not only to test the methods but to derive practical results. The idea behind the SHRP 2 tools is that since a major impact of operations projects is on travel time reliability, analysts need a way to predict the reliability impact of operations projects. Because safety was such a key concern of the MPO, it was included in the implementation effort.

TECHNICAL APPROACH TO RELIABILITY AND SAFETY FORECASTING FOR LRTP DEVELOPMENT
Because the LRTP development depends on results from the travel demand forecasting model (the Tampa Bay Regional Planning Model (TBRPM), which is based on the Cube software), it was decided that the most direct way to perform reliability and safety forecasting was to construct a postprocessor that uses the model outputs. Figure 1 shows the inputs and outputs for the Post-Processor. For reliability prediction, the SHRP 2 Project C11 procedure was chosen because it operates at a sketch planning level with a minimum of data inputs (3). For translating
the effect of operations projects into the independent variables in the C11 procedure, relationships from the Highway Economic Requirements System (HERS) model were used (4). Capital, operating, and maintenance costs of operations projects were obtained from the TOPS-BC documentation (5).

For safety prediction, safety performance functions (SPF) in the Highway Safety Manual (HSM) were chosen (6). Crash reduction factors (CRF) were compiled from FHWA’s Desk Reference (7). Locally developed costs were used for the safety costs of projects. How each of these methods were adapted in the Post-Processor is discussed below.

Reliability Prediction

SHRP 2 Project C11, Development of Improved Economic Impact Analysis Tools, focused on assessing the economic benefits of transportation investments beyond the traditional ones of travel time, safety, and vehicle operating costs. One of the impact areas identified was travel time reliability, and an economic analysis tool called the “Reliability Module” was developed to calculate reliability benefits. It is a sketch planning corridor spreadsheet tool that estimates the benefits of improving travel time reliability for use in benefit/cost analysis. The purpose of the Reliability Module is to allow users to quickly assess the effects of alternative highway investments in terms of both typical travel time and travel time reliability. The procedure is based on making estimates of recurring and nonrecurring congestion, combining them, and using predictive equations to develop reliability metrics.

Its predictive equations are based on a combination of past research efforts, including NCHRP, FHWA, and SHRP 2 Project L03. The C11 Module can be used as a standalone tool for doing sketch-planning-level analysis. However, a more useful application is to integrate it with a travel demand forecasting model as a postprocessor. Currently, the only tool that exists for estimating regional reliability impacts is the ITS Deployment Analysis System (IDAS) (8) and the FITSEval tool (9), but they are geared only to analyzing ITS and operations strategies. The postprocessor envisioned here is much simpler in scale and application. It allows planning agencies to make assessments of the regional impact of long-range transportation plans (LRTP) on reliability, in the same way that they currently assess regional VMT and delay. It also permits reliability to enter into the development and comparison of alternative improvements strategies, including operations, earlier in the LRTP development process. Finally, the technical relationships in the C11 model also are at the right scale to be incorporated into system planning tools.

The C11 Post-Processor is developed as a series of scripts written in the Statistical Analysis System (SAS). For input, the scripts read the loaded network file as well as a list of safety improvements. The analysis is conducted at the corridor level, using the 192 corridors present in the TBRPM. In summary, the procedure uses the following steps:

- Estimate recurring congestion using a volume-delay function
- Estimate incident delay using relationships from IDAS, then combine with recurring congestion to get average delay
- Use custom-developed relationships that predict reliability measures as a function of average delay (as described in the C11 procedure)

Performance Measures

- Planning Time Index (95th percentile travel time/free flow travel time)
- Reliability Index (80th percentile travel time/free flow travel time)
• Mean Travel Time Index (mean travel time/free flow travel time)

Methodology
The method in the original C11 tool was adapted as follows.

1. Assign Free Flow Speed (FFS)
   • Freeways: 65 mph
   • Arterials: 45 mph
   • Collectors: 40 mph
   • Ramps and local: 35 mph

2. Calculate Travel Time per Unit Distance (travel rate) for the Current and Forecast Years
   \[ t = \frac{(1+(0.1225*(v/c)^8))}{FFS}, \text{ for } v/c \leq 1.40 \]
   Where:
   \[ t = \text{travel rate (hours per mile)} \]
   \[ v = \text{volume (from loaded network file)} \]
   \[ c = \text{capacity (from loaded network file)} \]

   This volume-delay function is different than the one used in the TBRPM. However, we have found it to produce more reasonable estimates of speeds.

3. Compute the Recurring Delay in Hours per Mile
   \[ \text{RecurringDelayRate} = t - \frac{1}{FFS} \]

4. Compute the Delay Due to Incidents (IncidentDelayRate) in hours per mile. The lookup tables from the IDAS User Manual are used to calculate incident delay. This requires the \( v/c \) ratio, number of lanes, and length and type of the period being studied, which is set at 1 hour (for rural two-lane highways, use number of lanes = 2). This is the base incident delay.

   If incident management programs have been added as a strategy or if a strategy lowers the incident rate (frequency of occurrence), then the “after” delay is calculated as follows:
   \[ Da = Du * (1-Rf) * (1-Rd)^2 \]
   Where:
   \[ Da = \text{Adjusted delay (hours of delay per mile).} \]
   \[ Du = \text{Unadjusted (base)delay (hours of delay per mile, from the incident rate tables).} \]
   \[ Rf = \text{Reduction in incident frequency expressed as a fraction (where } Rf = 0 \text{ means no reduction, and } Rf =.30 \text{ means a 30 percent reduction in incident frequency).} \]
   \[ Rd = \text{Reduction in incident duration expressed as a fraction (where } Rd = 0 \text{ means no reduction, and } Rd =.30 \text{ means a 30-percent reduction in incident duration).} \]

   Changes in incident frequency are most commonly affected by strategies that decrease crash rates. However, crashes are only about 20 percent of total incidents. So, a 30 percent reduction in crash rates alone would reduce overall incident rates by \( .30 \times .20 = .6 \).

5. Compute the Overall Mean Travel Time Index (TTIm) which includes the effects of recurring and incident delay:
   \[ TTIm = 1 + FFS \times (\text{RecurringDelayRate} + \text{IncidentDelayRate}) \]
   Where: 
   \[ \text{IncidentDelayRate} \text{ is either } Du \text{ or } Da \]

   Because the data on which the reliability metric predictive functions do not include extremely high values of TTIm, it is recommended that TTIm be capped at a value of 6.0, which roughly corresponds to an average speed of 10 mph. Even though the data included highway sections that were considered to be severely congested, an overall annual average speed of
10 mph for a peak period was never observed. At TTIm = 6.0, the reliability prediction equations are still internally consistent.

6. Develop Custom Equations for Predicting Reliability Metrics. Instead of relying on the C11 tool’s equations, developed from data from several cities, it was decided to recalibrate them using data from Tampa. Freeway detector data for the Tampa area for 2010 through 2012 were obtained and analyzed for this purpose. Figure 2 shows the new equation to predict the 95th percentile travel time index (TTI).

The equations for predicting reliability for Tampa roadways are:

\[ TTl95 = 1 + 3.3000 \times \ln(TTIm) \]
\[ TTl80 = 4.2935/(1 + 20.1851 \times \exp(-1.8091 \times TTIm)) \]

7. Scheduling Projects for Improvements. The loaded network file that is output from the TBRPM is used as the basis for scheduling improvements. This file has the forecasted traffic volumes on the network links along with information about the physical capacity of those links. Roadway sections are scheduled for improvement if the either the AM or PM peak-period volume-to-capacity ratio is greater than or equal to 0.8. (The AM peak period is 2.5 hours long and the PM peak period is three hours long.)

The impact of making transportation improvements on the input variables (i.e., what change in inputs does a strategy effect?) were adapted from the Federal Highway Administration’s (FHWA) Highway Economic Requirements System (HERS) model. HERS is used to estimate the national future highway needs and the impacts of improvement strategies, including operations strategies.

Safety Prediction

**Performance Measures**

- Total crashes reduced
- Fatal crashes reduced
- Bicycle/pedestrian crashes reduced

**Methodology**

The basis of the crash prediction methods is the *Highway Safety Manual*, a comprehensive set of procedures for analyzing and predicting safety on highway facilities. For safety, crashes by daily time period are not computed—the entire day is used. It is based on producing an expected number of crashes using a statistical procedure known as the Empirical Bayes (EB) method, where total crashes for a facility are a weighted combination of actual crashes and predicted crashes from a safety performance function (SPF):

\[ \text{Expected Crashes} = (w \times \text{Predicted Crashes}) + \{(1-w) \times \text{Observed Crashes}\} \]

Where: \( w \) is a weighting factor based on the goodness-of-fit of the SPF.

This method is used to control for the high variability in the number of annual crashes on short- and/or low-volume segments.

The Hillsborough MPO had developed a dataset of crashes linked to the TBRPM network for computing observed crashes in the above equation. However, these included only fatal and incapacitating injuries; minor injuries and property damage only (PDO) crashes are excluded. The first step was to estimate the crashes for these other severity levels. The National Highway Traffic Administration’s (NHTSA) General Estimate System (GES) for 2012 was analyzed to develop factors for urban crashes. Analysis of GES data revealed that 70 percent of urban crashes were PDO, 25 percent of crashes were nonincapacitating or possible injury, and
3 percent were fatal or incapacitating injury. (Two percent had unknown severity.) So the factors are:

- (nonincapacitating + possible injury crashes) = (25/3) * (fatal + incapacitating)
- PDO crashes = (75/3) * (fatal + incapacitating)

The next step involved adapting the HSM’s SPFs for the predicted crashes term in the above equation. The SPFs are of the general form:

\[ \text{exp}[a + b \times \ln(AADT) + \ln(L)] \]

Where: L = length of roadway segment (miles)

a, b = regression coefficients that vary with general design parameters

The SPFs that were used are as follows.

- Arterials and Collectors
- Segment, multiple vehicle, nondriveway
- Segment single vehicle, nondriveway
- Segment, multiple vehicle, driveway
- Intersection, multiple vehicle
- Intersection, single vehicle
- Entire section, pedestrian
- Entire section, bicycle

After total crashes are obtained using the EB formula, a base year crash rate is computed. Future crashes (2040) are calculated by multiplying the future AADT by the base crash rate. Crashes per mile also are calculated.

Once the base number of crashes is established for 2040, the Post-Processor uses the following steps to identify safety-deficient highway sections for a given investment level. Three investment levels are used. Only arterials and collectors within the urban area were considered in the safety analysis; freeways and local streets were excluded.

- Priority corridors are scheduled first, followed by the remaining arterials, then collectors. The priority corridors were previously defined by MPO and represent sections of major highways in Hillsborough County.
- Crashes per mile for each roadway section is used to sort the sections in descending order.
- Roadway sections are scheduled for improvement if their crashes per mile are higher than the overall average values for Hillsborough County roadways: 21 crashes per mile for arterials and 8 crashes per mile for collectors. The difference in values is due to generally higher traffic on arterials.
- The procedure starts at the top of the list and selects roadway sections in order. Once selected, the cost of making the improvement and the number of crashes reduced are calculated using the factors presented in the tables presented in the Results section. These are tallied at the end of the selection process to produce total cost and crash reduction values.
- Roadway sections are selected from the sorted list until either: the total budgets are expended or all sections above the crashes per miles thresholds are selected, depending on the scenario.
POST-PROCESSOR RESULTS

Travel Time Reliability
Two types of operational improvements are considered for arterials: 1) traditional geometric treatments at intersections and 2) advanced coordinated signal control. For freeways, incident management and advanced operations treatments were used. The advanced operations treatments were defined as bundle that includes ramp metering, variable speed limits, and lane control. The unit costs for the improvement types were compiled from FHWA’s TOPS-BC tool; both capital and operating costs over the 20-year horizon are included. Table 1 shows the results for each scenario. The results were compiled on a corridor-by-corridor basis using the impact factors for each improvement type shown in the last column of Table 1.

If a roadway section was scheduled for improvement, then either: the capacity was increased, incident impacts were reduced, or both (depending on the investment scenario). Then, the reliability metrics were calculated for the “improved” case using the same equations as for the base condition. The reliability metrics were computed separately for the AM and PM peak periods, then combined as a VMT-weighted average (Table 2).

Safety (Crashes)
For the “Low” and “Medium” investment levels, a fixed budget was used–sections were improved until the budget was expended. For the “High” investment level, no budget was specified–all sections that had crash rates higher than the average rate were scheduled for improvement. Table 3 is a summary of costs and benefits, depending on the level of investment. Table 4 shows just the crash reductions for each investment level, compared to the 2040 base which assumes no safety improvements take place.

INCLUSION OF OPERATIONS AND SAFETY PROJECTS INTO THE IMAGINE 2040 PLAN
Benefits and costs for multiple investment scenarios were developed for each of the five goal categories listed in the Introduction. Then, the resulting 2040 system performance forecasts were used as part of a public engagement program for the long-range transportation plan, asking citizens to choose their preferred level of investment and corresponding performance outcome. Figure 3 shows the interactive tool that was used to gather public input.

For example, travel time reliability was a performance measure in the “Minimize Traffic for Drivers and Shippers” category of projects. Investing in advanced traffic management systems does not produce a quantifiable benefit when using typical macrolevel travel demand forecasting models that focus on capacity. Focusing instead on reliability produced a quantifiable benefit using the Post-Processor. Those benefits were then paired with cost estimates for the ATMS and other operational improvements, to let citizens create their own preferred budgets for the long-range plan.

The performance outcomes also carried a lot of weight in the “Reduce Crashes and Vulnerability” program. Reducing crashes by 20 percent (our Medium investment level) or by 50 percent (our High investment level) was appealing to many residents, in spite of the expense. When shown the performance outcomes, many citizens chose to spend more than the county’s current budget levels, even though the website and the PowerPoint presentations pointed out that a higher investment level likely means raising taxes. These charts summarize the responses (Figure 4).
To explore the various investment options preferred by the public, several financial scenarios were prepared for the MPO board’s consideration. The scenarios varied by spending pattern and also by whether they included new funding sources for transportation, such as mobility fees on new development or increases in the gas tax or sales tax.

Public preferences for higher performance outcomes supported the board in choosing to include a new local-option sales tax for transportation in the long-range transportation plan. The preferred investment levels in Congestion Management and in Crash Reduction were increased from today’s Low level to High (Level 3) and Medium-High (between Level 2 and Level 3) respectively. His financial scenario is the basis for Hillsborough MPO’s adopted 2040 Plan. Postadoption, public meetings are being held to discuss next steps, including the term of the new proposed tax, specific projects, and date of the public referendum to approve the tax.

SUMMARY AND FUTURE ENHANCEMENTS

The SHRP 2 Project C11 methodology for predicting travel time reliability was successfully implemented for the Hillsborough County MPO. Rather than using the standalone spreadsheet developed by Project C11, the methodology was implemented as a postprocessor to the MPO’s travel demand model. In addition, procedures in the Highway Safety Manual for predicting crashes were added to the C11 Post-Processor. Application of the Post-Processor for the 2040 update to the Hillsborough County LRTP produced project lists and associated costs for making improvements, as well as the reliability and safety impacts of those improvements. The operations and safety projects identified by the Post-Processor have been included in the LRTP.

Several recommendations are made to advance the use of the Post-Processor, and thereby encouraging that reliability and safety can be included in transportation plans:

- Develop “user-grade” software. The Post-Processor currently exists as a set of code that can be manipulated by a knowledgeable researcher. However, it is not designed to be user friendly, and its input and output interfaces would have to be improved if it is to operate by planning staff.

- Apply the Post-Processor to support other Florida MPOs’ LRTP updates. Because all MPOs in Florida use the Cube travel demand forecasting software, he file structures are the same.

- Adapt the C11 Post-Processor for statewide planning. While the Post-Processor is set up to work with a travel demand model, it is possible to extract its reliability and safety prediction methods to improve impact analysis in FDOT’s statewide planning.

- Account for synergies between safety and capital expansion/operations projects. Currently, the methodology considers safety and other projects in isolation. However, safety projects can also improve congestion conditions and operations and capital projects aimed at congestion can also have a positive safety impact.

- Consider adding demand variability to the methodology to capture reliability more completely.
FIGURE 1  Overview of operations on safety integration into the LRTP.
FIGURE 2 Relationship between average conditions and reliability for Tampa freeways.

FIGURE 3 Interactive public engagement tool.
FIGURE 4 Response of the public to LRTP investments.
<table>
<thead>
<tr>
<th>Analysis</th>
<th>Scenario</th>
<th>Representative Improvement Types</th>
<th>20-Year Cost</th>
<th>Impact Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations/Congestion Management</td>
<td>Low</td>
<td>Arterial operations improvements on Priority corridors only: intersection traffic responsive control.</td>
<td>$295M</td>
<td>Arterial capacity: +7%</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>The Low Scenario plus the following additions: Arterial intersection geometric upgrades on Priority corridors only (new signals, controllers, pedestrian signals and refuges, turn lanes/bays, cross walks, sidewalks, lighting, curbs and gutters, shoulders). Freeway operations: incident management only.</td>
<td>$806M</td>
<td>Arterial capacity: +17% Incident frequency: -5% Incident duration: -25%</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Same arterial improvements as the Medium Scenario. Freeway operations: Incident management, ramp metering, variable speed limits, lane control.</td>
<td>$957M</td>
<td>Arterial capacity: +17% Incident frequency: -7% Incident duration: -25% Freeway capacity: +10%</td>
</tr>
</tbody>
</table>

TABLE 1 Operations Investment Scenarios
TABLE 2 Reliability Analysis Results

<table>
<thead>
<tr>
<th>Highway Type</th>
<th>Mobility Measure</th>
<th>2040 Scenario</th>
<th>Investment Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Freeways</td>
<td>Average TTI</td>
<td>Base</td>
<td>1.580</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Improvements</td>
<td>1.580</td>
</tr>
<tr>
<td></td>
<td>80th percentile TTI</td>
<td>Base</td>
<td>1.891</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Improvements</td>
<td>1.891</td>
</tr>
<tr>
<td></td>
<td>Planning Time Index</td>
<td>Base</td>
<td>2.206</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Improvements</td>
<td>2.206</td>
</tr>
<tr>
<td></td>
<td>Centerline Miles Improved</td>
<td>0</td>
<td>120</td>
</tr>
<tr>
<td>Arterials</td>
<td>Average TTI</td>
<td>Base</td>
<td>1.717</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Improvements</td>
<td>1.602</td>
</tr>
<tr>
<td></td>
<td>80th percentile TTI</td>
<td>Base</td>
<td>2.065</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Improvements</td>
<td>1.930</td>
</tr>
<tr>
<td></td>
<td>Planning Time Index</td>
<td>Base</td>
<td>2.431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Improvements</td>
<td>2.254</td>
</tr>
<tr>
<td></td>
<td>Centerline Miles Improved</td>
<td>425</td>
<td>425</td>
</tr>
<tr>
<td></td>
<td>Intersections Improved</td>
<td>650</td>
<td>650</td>
</tr>
</tbody>
</table>

1 The Planning Time Index is the 95th percentile travel time index
### TABLE 3 Costs and Benefits of Safety Bundles

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Scenario</th>
<th>Representative Improvement Types</th>
<th>Improvement Costs</th>
<th>Budget</th>
<th>Impact Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Low</td>
<td>Minor intersection upgrades (new signal heads, phasing, signal heads), sidewalks. $200K per mile; crash reduction = 10%.</td>
<td>$200,000/mile</td>
<td>$64,000,000</td>
<td>Crash Reduction Factor = 10%</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>Major intersection upgrades (new signal heads, controllers, pedestrian signals and refuges, turn lanes/bays, crosswalks, sidewalks).</td>
<td>$500,000/mile</td>
<td>$320,000,000</td>
<td>Crash Reduction Factor = 25%</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>Major intersection upgrades (new signals, controllers, pedestrian signals and refuges, turn lanes/bays, crosswalks, sidewalks, lighting, complete streets, hazard removal median treatments, curbs and gutters, shoulders).</td>
<td>$1,000,000/mile</td>
<td>No budget constraint—all sections above the average crash rate are improved.</td>
<td>Crash Reduction Factor = 55%</td>
</tr>
</tbody>
</table>

### TABLE 4 Crash Reduction Costs and Benefits

<table>
<thead>
<tr>
<th>Investment Level</th>
<th>Benefits</th>
<th>Responsible Agency</th>
<th>Description</th>
<th>Annual Cost</th>
<th>20-Year Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Total crashes are reduced by 4,390 (9%) Total fatal crashes reduced by 13 (9.7%) Bike/pedestrian crashes reduced by 136</td>
<td>Hillsborough</td>
<td>intersections, medians, sidewalks, school safety</td>
<td>$11,315,000</td>
<td>$226,300,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>City of Tampa</td>
<td>Sidewalks, bikeways, crosswalks</td>
<td>$5,768,638</td>
<td>$115,372,768</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temple Terrace</td>
<td>Sidewalks, bike lanes, ADA curbs</td>
<td>$132,760</td>
<td>$2,655,200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plant City</td>
<td>Intersections, sidewalks</td>
<td>$112,000</td>
<td>$2,240,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FDOT</td>
<td>Education, enforcement, grants to local agencies</td>
<td>$7,586,600</td>
<td>$151,732,000</td>
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</tbody>
</table>

**Level 1 Total** $24,914,998.4 $498,299,968
<table>
<thead>
<tr>
<th>Investment Level</th>
<th>Benefits</th>
<th>Responsible Agency</th>
<th>Description</th>
<th>Annual Cost</th>
<th>20-Year Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2</td>
<td>Total crashes are reduced by 9,017 (20.2%)</td>
<td>All</td>
<td>903 intersection treatments: signal adjustments, pedestrian signals and refuge areas, turn lanes/bays, crosswalks</td>
<td>$22,575,000</td>
<td>$451,500,000</td>
</tr>
<tr>
<td></td>
<td>Total fatal crashes reduced by 28 (20.2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bike/pedestrian crashes reduced by 294</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All 903 intersection treatments: signal adjustments, pedestrian signals and refuge areas, turn lanes/bays, crosswalks</td>
<td>Hillsborough County</td>
<td>600 miles of new standard street lights, including operational cost for 20 years</td>
<td>$21,000,000</td>
<td>$420,000,000</td>
</tr>
<tr>
<td></td>
<td>All 300 miles of new sidewalks for continuous sidewalk on at least one side of all major roads</td>
<td></td>
<td></td>
<td>$2,400,000</td>
<td>$48,000,000</td>
</tr>
<tr>
<td><strong>Level 2 Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$45,975,000</strong></td>
<td><strong>$919,500,000</strong></td>
</tr>
<tr>
<td>Level 3</td>
<td>Total crashes are reduced by 22,722 (50.8%)</td>
<td>All</td>
<td>903 miles of “complete streets” treatments on major roads with above-average crash rate</td>
<td>$87,918,338</td>
<td>$1,758,366,750</td>
</tr>
<tr>
<td></td>
<td>Total fatal crashes reduced by 68 (50.7%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bike/pedestrian crashes reduced by 704</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All 903 miles of “complete streets” treatments on major roads with above-average crash rate</td>
<td>Hillsborough County</td>
<td>600 miles of new standard street lights, including operational cost for 20 years</td>
<td>$21,000,000</td>
<td>$420,000,000</td>
</tr>
<tr>
<td></td>
<td>All 300 sidewalk miles, for continuous sidewalk on at least one side of all major roads</td>
<td></td>
<td></td>
<td>$2,400,000</td>
<td>$48,000,000</td>
</tr>
<tr>
<td><strong>Level 3 Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$111,318,338</strong></td>
<td><strong>$2,226,366,750</strong></td>
</tr>
</tbody>
</table>
TABLE 5 Crash Reductions Due to Safety Investments (Arterials and Collectors, Hillsborough County)

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Base</th>
<th>Level 1 ($64M)</th>
<th>Level 2 ($320M)</th>
<th>Level 3 (Unlimited)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>44,741</td>
<td>43,122 (-9%)</td>
<td>37,773 (-20%)</td>
<td>22,019 (-51%)</td>
</tr>
<tr>
<td>Fatal</td>
<td>134</td>
<td>129 (-10%)</td>
<td>113 (-20%)</td>
<td>66 (-51%)</td>
</tr>
<tr>
<td>Bike/Pedestrian</td>
<td>1,387</td>
<td>1,337 (-4%)</td>
<td>1,171 (-16%)</td>
<td>683 (-50%)</td>
</tr>
</tbody>
</table>
REFERENCES


