Designing Walkable Urban Thoroughfares:  
A Context Sensitive Approach – Phase III 
Outreach Materials (Task 5)

PERFORMANCE MEASURES
Technical Memorandum

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Performance measures help the transportation professional quantify the performance and benefits of the context sensitive solutions (CSS) process and evaluate design outcomes.

**THIS TASK**

The current project is intended to prepare and provide transportation professionals and decision makers with useful information associated with performance measures for the design of context sensitive urban thoroughfares. This task provides:

- A review of past efforts to develop and apply performance measures to evaluate CSS processes and outcomes; and
- A structure for and examples of performance measures that can be used to evaluate applications from the recently published ITE recommended practice *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*.¹

The focus of this effort is to provide a framework and approach intended as a starting point for the development of a more complete process and performance measurement tool. The scope of work for the development of a more comprehensive set of performance measures and evaluation process is included at the conclusion of this paper.

**THIS MEMORANDUM**

This memorandum provides a summary of performance measurement of CSS and related approaches to thoroughfare design. It proposes a structure for evaluating urban thoroughfare planning and design processes as well as the designs and outcomes. Examples of performance measures are included. It concludes with a proposed scope of work to complete a guide for using performance measures to assess the process and outcomes of urban thoroughfares designed using CSS.

**USE AND OVERUSE OF PERFORMANCE MEASURES**

Performance measurement can be a very valuable tool. Measures can be devised to quantify many aspects of a project and its benefits and impacts. However, experience has shown that while any number of performance measures can be employed for a given purpose, once the number exceeds about eight measures, the sensitivity of the resulting composite performance rating declines significantly. That results in different options starting to perform more similarly. This usually occurs because

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some considerations offset others.

As a result, it is good practice to base an evaluation on the 6–8 most important objectives or issues. In some cases more will have to be considered. However, in such cases weighting can be used to incorporate relative importance into the process.

**PRINCIPLES, QUALITIES, AND OUTCOMES OF CSS**

Several principles, qualities, and outcomes were established in the 1998 *Thinking Beyond the Pavement* conference that discussed how to develop a better approach to designing thoroughfares so they would better fit into and support their surroundings. Those principles were refined in subsequent AASHTO and FHWA strategic meetings. The resulting principles, qualities, and outcomes of using CSS as a process as well as a planning and design approach are as follows.

**Core Principles of CSS**

These core CSS principles apply to transportation processes, outcomes, and decision making:

1. Strive toward a shared stakeholder vision to provide a basis for decisions.
2. Demonstrate a comprehensive understanding of contexts.
3. Foster continuing communication and collaboration to achieve consensus.
4. Exercise flexibility and creativity to shape effective transportation solutions while preserving and enhancing community and natural environments.

**CSS Qualities**

Context sensitive solutions is guided by a process that:

1. Establishes an interdisciplinary team early, including a full range of stakeholders, with skills based on the needs of the transportation activity.
2. Seeks to understand the landscape, the community, valued resources, and the role of all appropriate modes of transportation in each unique context before developing engineering solutions.
3. Communicates early and continuously with all stakeholders in an open, honest, and respectful manner and tailors public involvement to the context and phase.
4. Utilizes a clearly defined decision-making process.
5. Tracks and honors commitments through the life cycle of projects.
6. Involves a full range of stakeholders (including transportation officials) in all phases of a transportation program.
7. Clearly defines the purpose and seeks consensus on the shared stakeholder vision and scope of projects and activities, while incorporating transportation, community, and environmental elements.

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8. Secures commitments to the process from local leaders.
9. Tailors the transportation development process to the circumstances and uses a process that examines multiple alternatives, including all appropriate modes of transportation, and results in consensus.
10. Encourages agency and stakeholder participants to jointly monitor how well the agreed-upon process is working, to improve it as needed, and when completed, to identify any lessons learned.
11. Encourages mutually supportive and coordinated multimodal transportation and land-use decisions.
12. Draws upon a full range of communication and visualization tools to better inform stakeholders, encourage dialogue, and increase credibility of the process.

CSS Outcomes

Context sensitive solutions lead to outcomes that:

1. Are in harmony with the community and preserve the environmental, scenic, aesthetic, historic, and natural resource values of the area.
2. Are safe for all users.
3. Solve problems that are agreed upon by a full range of stakeholders.
4. Meet or exceed the expectations of both designers and stakeholders, thereby adding lasting value to the community, the environment, and the transportation system.
5. Demonstrate effective and efficient use of resources (people, time, budget) among all parties.

These principles, qualities, and outcomes define the basic approach and goals of CSS.

PERFORMANCE MEASUREMENT IN TRANSPORTATION

Performance measurement has been used for many decades in transportation. Among the most common applications are planning (e.g., project prioritization), environmental impact analysis (e.g., comparative evaluation of project alternatives), operations (e.g., travel time and delays), and maintenance (e.g., pavement condition). In fact, performance measurement has been applied in programs and projects using the CSS approach.

NCHRP Web Document 69, Performance Measures for Context Sensitive Solutions – A Guidebook for State DOTs, provides guidelines for measuring performance related to CSS principles for both transportation agencies and transportation projects and systems. Guidelines are presented to assist DOTs (not limited to state DOTs) to develop their own CSS performance measurement programs to assess programs and projects.

The scope used to define CSS and establish a scope for potential measurement is based on the AASHTO and FHWA policies that encourage state DOTs to incorporate CSS as an agency-wide

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philosophy. Agency-wide application of CSS is described as “a cohesive philosophy embodied in basic principles that address the project development process and outcomes of project implementation, agency-wide.” For transportation projects following CSS principles, the project “is designed collaboratively by an interdisciplinary team, which includes community and regulatory agency stakeholders and fits its physical setting by supporting community values and preserving scenic, aesthetic, historic, and environmental resources, while maintaining safety and mobility.” For the current use, the second description is more directly applicable. However, both are relevant to this task.

The report suggests that using performance measures for CSS can help project managers and project and implementation teams focus on the full range of customer needs for transportation projects. That is directly relevant to designing thoroughfares in urban areas.

This report contains four major sections:

- Guiding concepts for CSS performance measurement programs;
- Project-level focus areas;
- Organization-wise focus area; and
- Tips for getting started.

The guidelines are structured around two pairs of splits that create a matrix for structuring performance measurements for CSS applications:

- Project level and organization level; and
- Process and outcomes.

Those result in the matrix shown in Table 1. This table also shows the subject areas (not specific measures) suggested for measurement in each of the four cells. The report provides examples of performance measures that could be employed in each of the four cells but does not recommend specific measures. This is appropriate since each agency, project, and project area will have specific attributes for which measures may be needed. The report includes a dozen project and organization case study examples.

<table>
<thead>
<tr>
<th>Application</th>
<th>Type of Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Process</td>
</tr>
<tr>
<td>Organization</td>
<td>• Training</td>
</tr>
<tr>
<td></td>
<td>• Manuals</td>
</tr>
<tr>
<td></td>
<td>• Motivation</td>
</tr>
<tr>
<td></td>
<td>• Policies</td>
</tr>
<tr>
<td>Project</td>
<td>• Use of multi-disciplinary teams</td>
</tr>
<tr>
<td></td>
<td>• Public engagement</td>
</tr>
<tr>
<td></td>
<td>• Consensus on project needs, problems, opportunities</td>
</tr>
</tbody>
</table>
The interim report of NCHRP Project 8-74, *Sustainability Performance Measures for State DOTs and Other Transportation Agencies* expands the classification of types of performance measures.\(^5\) In addition to process and outcome measures, it adds output measures. It describes output measures as those that document results or changes to the transportation system and the way it functions.

This interim report also classifies the types of applications for which performance measures typically are used:

- **Describe** – understand status or trends of agency actions or facility operations.
- **Assess** – compares status or trends to targets or benchmarks.
- **Diagnose** – identifies what is right or wrong, the causes, and what can be done to improve.
- **Accountability** – identifies performance for which an agency or unit is responsible and how well it is performing.
- **Decision making** – evaluates, compares, prioritizes, or selects among options; may have thresholds used in go-no-go decisions.
- **Communication** – uses performance measures to describe results or other findings.

All of these applications could be used in a CSS project.

NCHRP Report 642, *Quantifying the Benefits of Context Sensitive Solutions*, goes further by detailing a number of the considerations within each of the above cells.\(^6\) The objective of this report was to “identify a comprehensive set of performance measures of CSS principles (that) quantifies the resulting benefits through all phases of project development.” The project behind this report concluded that there had been “few attempts to systematically develop metrics for quantifying the benefits of applying CSS” through the project development process. This project found 33 case studies to apply metrics and application processes that would cover each CSS principle. The report makes the point that each project is unique (nature, scope, issues, and their importance, etc.). These differences affect the way the CSS principles are applied and what performance measures may be applicable.

NCHRP Report 642 also identified criteria for a good set of performance measures:

- Valid.
- Reliable.
- Understandable.
- Timely.
- Resistant to perverse behavior.
- Comprehensive.

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\(^5\) Texas Transportation Institute, Cambridge Systematics, CH2M Hill, Hill Street Consulting Group, Henrick Gudmunsson, Ralph Hall, and Gregory Marsden, *Sustainability Performance Measures for State DOTs and Other Transportation Agencies*, Interim Report, NCHRP Project 8-74, Texas Transportation Institute, College Station, Texas, October 2010.

• Non-redundant.
• Sensitive to data collection cost.
• Focused on controllable facets of performance.

Another report listed desired attributes in a different way with different characteristics:⁷
• Acceptable.
• Accurate.
• Affordable.
• Appropriate level of detail.
• Have target or benchmark.
• Measurable.
• Relevant.
• Sensitive to changes.
• Show trends.
• Understandable to stakeholders.

Although the two lists have different contents, both lists are applicable.

NCHRP Report 642 concluded that customer satisfaction is often the goal being assessed. Tools and indicators to measure or assess customer satisfaction often have to be customized. This report also identified an approach to evaluation of CSS projects, which is embodied in Table 2. It starts with an overall goal that is generally applicable to any project and to which any (CSS) process should be directed. The core strategies and action principles are condensed versions of the CSS principles and strategies. The benefits (fundamental and more specific “potential”) were drawn from sources reviewed in that project.

One could classify core strategies and the action principles from Table 2 as process (per Table 1) and the benefits as outcomes. However, the benefits listed in this table are more comprehensive and specific than the CSS outcomes listed on page 3 of this memorandum. This project matched the principles to the benefits as shown in Table 3. It identified the cells of the matrix as fundamental, primary, secondary, and tertiary. This prioritization then shows which of the cells are most likely to be critical to use. Of course, that may vary with the specific project.

The project also identified both quantitative and semi-quantitative measures and indicators to apply to each of the potential benefits. These are shown in Table 4. Some indicators are very specific and directly quantifiable (e.g., under benefit 2, number/cost of change orders) while others are less specific and might need further definition or description to be quantified (e.g., under benefit 4, increased or enhanced mitigation beyond regulatory mandates). Nevertheless, this table provides the basis for establishing quantitative or qualitative indicators that can be used to assess performance of processes or outcomes of CSS projects. Specific projects may have goals, processes, or outcomes that might require additional indicators to quantify performance.

⁷ Ramani, Tara, Josias Zietsman, William Eisele, Duane Rosa, Debbie Spillane, and Brian Bochner, Developing Sustainable Transportation Performance Measures for TxDOT’s Strategic Plan, Technical Report 0-5541-1, Texas Transportation Institute, April 2009.
NCHRP Report 642 demonstrated how its suggested approach could be applied to projects. The report concluded with suggested steps for establishing an evaluation of benefits for a CSS project:

1. Determine the appropriate intensity of each principle based on the scope, scale, and context of the project (e.g., Table 3).
2. Determine the benefits to be measured and their metrics based on the desired benefit analysis.
3. Establish benchmarks for comparing measured outcomes for benefits.
4. Collect, maintain, and make accessible pertinent data for benefit evaluation.
5. Conduct a benefit analysis and evaluation.

A successful analysis requires that the evaluation approach be established from the outset of the project so it can track the level of accomplishment of objectives throughout the process. The CSS principles can be properly applied and data can be collected as the project development process proceeds.

The final report of NCHRP Project 25-25 Task 02, Transportation Impacts of Smart Growth and Comprehensive Planning Initiatives provides additional suggestions that are applicable in evaluating CSS design processes and projects outcomes. Smart growth objectives generally parallel those of CSS as it relates to regional or area-wide outcomes. Many of the processes used in smart growth are also similar. Designing Walkable Urban Thoroughfares: A Context Sensitive Approach addresses CSS considerations from the planning and design perspectives, but also from the local (project) and system (area) perspectives. Smart growth is applied to characteristics of the context that interacts with transportation projects in CSS. The NCHRP 25-25 Task 02 report suggests that monitoring (and therefore one could extend that to evaluation) should address the impacts of growth patterns, such as:

- Development patterns.
- Transportation conditions.
- Travel behavior.

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Table 2. Characteristics of a CSS principle driven and benefit justified project and process

<table>
<thead>
<tr>
<th>Primary Goal:</th>
<th>Find a “best fit” transportation solution for the context that meets expectations of the transportation agency, stakeholders, and community.</th>
</tr>
</thead>
</table>
| Core Strategies: | • Establish a shared stakeholder vision to provide a basis for decisions.  
• Demonstrate a comprehensive understanding of context.  
• Foster continuing communication and collaboration to achieve mutual success.  
• Exercise flexibility and creativity to shape transportation solutions.  
• Preserve and enhance community and natural environments. |
| Action Principles: | • Use interdisciplinary teams.  
• Involve stakeholders.  
• Seek broad-based public involvement.  
• Use full range of communication methods.  
• Achieve consensus on purpose and need.  
• Address alternatives and all modes.  
• Consider a safe facility for users & community.  
• Maintain environmental harmony.  
• Address community & social issues.  
• Address aesthetic treatments & enhancements.  
• Utilize full range of design choices.  
• Document project decisions.  
• Track and meet all commitments.  
• Use agency resources effectively.  
• Create a lasting value for the community. |
| Fundamental Benefits: | • Increased stakeholder/public participation, ownership, and trust.  
• Improved community satisfaction.  
• Design features appropriate to context.  
• Decreased costs for overall project delivery.  
• Minimized overall impact to human and natural environment.  
• Improved mobility for users.  
• Improved safety (vehicles, pedestrians, and bikes).  
• Improved quality of life for community.  |
| Potential Benefits: | • Improved predictability of project delivery.  
• Improved project scoping and budgeting.  
• Improved long-term decisions and investments.  
• Improved environmental stewardship.  
• Optimized maintenance and operations.  
• Increased risk management and liability protection.  
• Improved stakeholder/public feedback.  
• Increased stakeholder/public participation, ownership, and trust.  
• Decreased costs for overall project delivery.  
• Decreased time for overall project delivery.  
• Increased partnering opportunities.  
• Minimized overall impact to human and natural environment.  
• Improved mobility for users.  
• Improved walkability and bikeability.  
• Improved safety (vehicles, pedestrians, and bikes).  
• Improved multi-modal options (including transit).  
• Improved community satisfaction.  
• Improved quality of life for community.  
• Improved speed management.  
• Design features appropriate to context.  
• Minimized construction-related disruption.  
• Improved opportunities for economic development. |
Table 3. Strength of relationship between CSS principles and associated potential benefits

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improved predictability of project delivery</td>
<td></td>
</tr>
<tr>
<td>2. Improved project scope and budgeting</td>
<td></td>
</tr>
<tr>
<td>3. Improved line team decision and investments</td>
<td></td>
</tr>
<tr>
<td>4. Improved environmental stewardship</td>
<td></td>
</tr>
<tr>
<td>5. Optimized maintenance and operation</td>
<td></td>
</tr>
<tr>
<td>6. Improved risk management and liability protection</td>
<td></td>
</tr>
<tr>
<td>7. Improved stakeholder feedback</td>
<td></td>
</tr>
<tr>
<td>8. Increased stakeholder participation, engagement, and flair</td>
<td></td>
</tr>
<tr>
<td>9. Decreased costs for overall project delivery</td>
<td></td>
</tr>
<tr>
<td>10. Decreased time for overall project delivery</td>
<td></td>
</tr>
<tr>
<td>11. Increased emerging opportunities</td>
<td></td>
</tr>
<tr>
<td>12. Mitigated overall impact in human and natural environment</td>
<td></td>
</tr>
<tr>
<td>13. Improved mobility for users</td>
<td></td>
</tr>
<tr>
<td>14. Improved physical and mental health</td>
<td></td>
</tr>
<tr>
<td>15. Improved safety (workplace, transportation, and habitat)</td>
<td></td>
</tr>
<tr>
<td>16. Improved overall quality of life (including health)</td>
<td></td>
</tr>
<tr>
<td>17. Improved community satisfaction</td>
<td></td>
</tr>
<tr>
<td>18. Improved quality of life for community</td>
<td></td>
</tr>
<tr>
<td>19. Improved project management</td>
<td></td>
</tr>
<tr>
<td>20. Design flexibility appropriate to context</td>
<td></td>
</tr>
<tr>
<td>21. Increased connectivity and alignment</td>
<td></td>
</tr>
<tr>
<td>22. Increased opportunities for economic development</td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Fundamental
- Primary
- Secondary
- Tertiary
<table>
<thead>
<tr>
<th>Benefit</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improved predictability of project delivery</td>
<td>• Difference in project duration in months to complete</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>2. Improved project scoping and budgeting</td>
<td>• Number and cost of change orders/scope changes</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>3. Improved long-term decisions and investments</td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>4. Improved environmental stewardship</td>
<td>• Increased or enhanced mitigation beyond regulatory mandates</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>5. Optimized maintenance and operations</td>
<td>• Annual cost, hours, or closures in dollars</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>6. Increased risk management and liability protection</td>
<td>• Number and cost of legal action taken against project</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>7. Improved stakeholder/public feedback</td>
<td>• Number of stakeholder/public responses</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>8. Increased stakeholder/public participation, ownership, and trust</td>
<td>• Stakeholder involvement measures</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion and satisfaction level</td>
</tr>
<tr>
<td>9. Decreased costs for overall project delivery</td>
<td>• Decreased dollar cost amount for project delivery</td>
</tr>
<tr>
<td></td>
<td>• Number and cost of change orders/scope changes</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>10. Decreased time for overall project delivery</td>
<td>• Number of months by project phases and total duration</td>
</tr>
<tr>
<td></td>
<td>• Number and cost of change orders/scope changes</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>11. Increased partnering opportunities</td>
<td>• Number of Memorandums of Agreement or grants established</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>12. Minimized overall impact to human and natural environment</td>
<td>• Percentage of human and environmental impacts of project</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>13. Improved mobility for users</td>
<td>• Each modal facility element inclusion and extent</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>14. Improved walkability and bikeability</td>
<td>• New and expanded options for pedestrians and bicyclists</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>15. Improved safety (vehicles, pedestrians, and bikes)</td>
<td>• Change in crashes, crash rate and severity</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>16. Improved multi-modal options (including transit)</td>
<td>• New and/or expanded modal choices</td>
</tr>
<tr>
<td></td>
<td>• Modal connectivity (count/volume)</td>
</tr>
<tr>
<td></td>
<td>• Modal safety (crash/severity)</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>17. Improved community satisfaction</td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>18. Improved quality of life for community</td>
<td>• Alignment with community plans (semi-quantitative)</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>19. Improved speed management</td>
<td>• Operating speed (expected/actual)</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>20. Design features appropriate to context</td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>21. Minimized construction-related disruption</td>
<td>• Work zone, lane closings, and detour duration in days</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
<tr>
<td>22. Improved opportunities for economic development</td>
<td>• Number of Memorandums of Agreement/grants established</td>
</tr>
<tr>
<td></td>
<td>• Semi-quantitative assessment of opinion</td>
</tr>
</tbody>
</table>
Such assessments, when applied to CSS, would need to be kept relevant to the project, its context, and the goals and objectives for the context, with the understanding that objectives often involve supporting, facilitating, or encouraging change in the context. CSS projects may also involve or depend on changes in the regional transportation network to achieve project (and context) objectives.

Chapter 4 of that report suggests a number of indicators that can be used to measure project or areawide transportation system performance as well as context changes.

In a paper titled *Characteristics and Performance of Smart Growth Transportation Systems*, the authors describe transportation network and operational characteristics. Some of these characteristics are similar to guidelines contained in *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*. Indicators are suggested, including:

For *supply* (key aspects of a smart growth transportation system):
- Block size
- Street network density
- Intersection density
- Percentage of four-way intersections
- Percentage of major-minor intersections
- Transit revenue-hour density
- Transit stop density

For system *performance* (usable only when the CSS project requires or accommodates system changes):
- VMT per capita
- Vehicle hours of travel per capita
- Average vehicle trip length
- Vehicle trips per capita
- Vehicle ownership per household
- Average annual delay per peak-hour traveler
- Transit trips per capita
- Vehicle emissions per capita (ozone non-attainment and maintenance areas only)
- Vehicle crash fatalities per capita and per VMT

Not all of these measures are appropriate for a CSS performance measurement.

*Scoring Formula for New Jersey’s Main Streets* more specifically addresses characteristics that are relevant to a CSS urban thoroughfare design. The researchers examined characteristics that cause main street stakeholders to consider a street to attain main street status. This was done by using stakeholder visual preference surveys and correlating the preferences to physical and

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10 Ewing, Reid, Michael King, and Sophie Hartshorn, *Scoring Formula for New Jersey’s Main Streets*, Alan M. Voorhees Transportation Center, Rutgers University, March 2003.
operational characteristics. These could be considered as characteristics that could be measured to evaluate achievement of objectives for some CSS projects.

Examples of context-related characteristics for use to quantify context outcomes include:
- Proportion of street frontage with parked cars.
- Proportion of street frontage with tree canopy.

Examples of design outcomes include:
- Visible curb extension.
- Crosswalk length.
- Average median width.

Operations examples include:
- Vehicular traffic volume (or photograph presence).
- Pedestrian volume (or photograph presence).

This report identified the characteristics with statistically significant effects on main street survey scores.

“Transportation and Sustainability: Best Practices Background” suggests a number of design features that are directly applicable to CSS and could be quantified in an evaluation of CSS accomplishment or benefits. Examples are shown in Table 5. If consistent with project objectives, the presence or density of such features could be used as performance measures. Better yet would be the results of these features such as percentage of precipitation not reaching storm sewers (as a result of porous pavements).

Greenroads is a sustainability performance metric for roadways that considers sustainability practices. A Greenroad is a roadway project that has been designed and constructed to a level of sustainability that is substantially higher than current common practice. This manual addresses some of the same characteristics as a CSS evaluation would since their objectives are often very close. CSS would be considered a subset of Greenroads sustainability. In fact, CSS is one of the 49 credit areas that are included in this manual. Table 6 shows the credit areas that are addressed in the manual. Some beyond the CSS credit (AE-3) could be applicable in a CSS evaluation and the metrics described in the manual could be used or adapted. The CSS credit is a checklist of sorts with a 5-point rating based on the proportion of listed steps that are accomplished.

---

Table 5. Potential CSS project design features

<table>
<thead>
<tr>
<th>Objective</th>
<th>Examples of Design Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce energy consumption</td>
<td>• Traffic signal coordination/optimization&lt;br&gt;• Low energy lighting&lt;br&gt;• Dedicated transit lanes&lt;br&gt;• Bike lanes&lt;br&gt;• Transit signal priority</td>
</tr>
<tr>
<td>Reduce consumption of material resources</td>
<td>• Recycled aggregates&lt;br&gt;• Narrow traffic lanes&lt;br&gt;• Fewer luminaire poles/catenary lighting system&lt;br&gt;• Higher strength concrete pavements&lt;br&gt;• Precast or modular construction elements</td>
</tr>
<tr>
<td>Reduce impacts to environmental resources</td>
<td>• Rain gardens for storm water infiltration&lt;br&gt;• Diverse plant/tree selections&lt;br&gt;• Storm water infiltration basins in planter strips&lt;br&gt;• Porous pavement&lt;br&gt;• Wildlife crossings</td>
</tr>
<tr>
<td>Support vibrant urban communities</td>
<td>• Noise reducing pavement materials&lt;br&gt;• Public art&lt;br&gt;• Pedestrian refuges in medians&lt;br&gt;• Emergency vehicle access</td>
</tr>
<tr>
<td>Support sustainability during implementation</td>
<td>• Reclamation of demolition materials&lt;br&gt;• Use of renewable fuels for construction equipment&lt;br&gt;• Use of locally obtained materials&lt;br&gt;• Access to affected businesses&lt;br&gt;• Minimize construction “footprint”</td>
</tr>
</tbody>
</table>


The Federal Highway Administration is currently developing a sustainable highways self-evaluation tool. The Sustainable Highways Self-Evaluation Tool identifies characteristics of sustainable highways and provides procedures and techniques to help agencies and organizations apply and integrate sustainability best practices into highway and other roadway projects and programs within system planning, project development, and operations and maintenance. It is intended for use for all roadways, not just highways. Credits are organized into three categories: system planning, project development, and operations and maintenance. Table 7 shows the list of credit categories. There are 67 credits in the tool (beta test version). Each credit contains a description of how to assess the degree of sustainability achieved.

---

In the description of its recommended framework for measuring aspects of asset management, NCHRP Report 551, *Performance Measures and Targets for Transportation Asset Management*, the research team provided guidance for selecting measures: \(^\text{14}\)

1. Inventory and review existing performance measures and identify how they are being used.
2. Identify gaps to be addressed based on coverage of critical output/outcome areas for the established goals, objectives, and interests.
3. Define criteria for new measures.
4. Identify additional candidate measures.
5. Select most appropriate measures from the list of candidates.

Table 7. FHWA sustainability self-evaluation tool credits

<table>
<thead>
<tr>
<th>System Planning and Processes Credits</th>
<th>Project Development Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credit</strong></td>
<td><strong>Credit</strong></td>
</tr>
<tr>
<td>SP-1 Comprehensive and Integrated Planning</td>
<td>PD-1 Cost-Benefit Analysis</td>
</tr>
<tr>
<td>SP-2 Environmental Management System</td>
<td>PD-2 Highway and Traffic Safety</td>
</tr>
<tr>
<td>SP-3 Contact Sensitivity Solutions (CSS)</td>
<td>PD-3 Contact Sensitivity Solutions (CSS)</td>
</tr>
<tr>
<td>CP-4 Equity Analysis</td>
<td>PD-4 Life-cycle Assessment</td>
</tr>
<tr>
<td>SP-5 Land Use Planning Integration</td>
<td>PD-5 Life-cycle Cost Analysis</td>
</tr>
<tr>
<td>SP-6 Multimodal Transportation</td>
<td>PD-6 Freight Mobility</td>
</tr>
<tr>
<td>SP-7 Professional Development</td>
<td>PD-7 Economic Development</td>
</tr>
<tr>
<td>SP-8 Travel Demand Management</td>
<td>PD-8 Habitat Restoration</td>
</tr>
<tr>
<td>SP-9 Safety Planning</td>
<td>PD-9 Rollof Flow Control</td>
</tr>
<tr>
<td>SM-10 Air Quality</td>
<td>PD-10 Rollof Quality</td>
</tr>
<tr>
<td>ST-11 Greenhouse Gas Emissions</td>
<td>PT-11 Ecological Connectivity</td>
</tr>
<tr>
<td>SP-12 Climate Change Effects</td>
<td>PD-12 Low Impact Development</td>
</tr>
<tr>
<td>SP-13 Noise Reduction Management Plan</td>
<td>PD-13 Recycled Materials</td>
</tr>
<tr>
<td>SP-14 Financial Sustainability</td>
<td>PD-14 Renewable Energy</td>
</tr>
<tr>
<td><strong>System Planning and Processes Score</strong></td>
<td><strong>Project Development Score</strong></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

This report also suggests several steps that can be used to establish performance targets, where needed. Adapting those steps to CSS planning and design, the steps would be:

1. Define the context for target setting and establish time horizon(s).
2. Consider goals, future time periods, and technical and economic factors.
3. Determine which measures should have targets.
5. Consider policy and public input implications associated with target setting.
6. Establish targets and track progress.

The report also lists several categories of performance measures that could be applicable in the various project development phases such as:

- Accessibility.
- Mobility.
- Environmental impacts.
• Economic development.
• Social impacts.
• Operations.
• Maintenance.
• Preservation.
• Safety.
• Security.
• Project delivery.
• Cost and cost-effectiveness.

The report also lists several characteristics that are useful in selecting measures to use:

• Easy to understand and interpreted consistently.
• Well defined.
• Quantifiable.
• Credible.
• Describes existing (or past or future) conditions.
• Can be predicted.
• Implementable with existing (or available) resources.
• Reasonable accuracy.
• Reasonable precision.
• Applicable to multiple modes.
• Shows change.
  o (Item being measured) changes over time.
  o Varies by alternative being considered.
• Characteristic can be controlled or changed.
• Measure captures or users’ experience.
• Reflects outcomes.
• Supports or describes performance related to goals, objectives.
• Applicable and meaningful across project, network, context, and/or agency(s) as would be applied.
• Compatible with applicable policy, guidelines, criteria.
• Data available and reliable.
• Targets (or benchmarks) can be established where applicable.

This report also addressed the construction of measures and categorized some types:

• Number or value—for example, total VMT, total travel time, average travel speed, total number of injury-only crashes, pavement serviceability index, and area of bridge deck cracking.
• Rate—for example, crashes per 100 million VMT, incidents per million passenger-miles traveled (PMT), and operating cost (or revenue) per million seat-miles.
• Ratio—for example, fatal to nonfatal accidents, bus ridership to rail ridership, and travel time in congested conditions to travel time in free-flow conditions.
Each type can provide a different insight. The challenge is to select the types that most appropriately show the performance or comparative performance that addresses the goal, objective, or interest being evaluated.

Finally this report suggests a process for integrating performance measures into an organization. Those applicable to the CSS approach to design of walkable urban thoroughfares include:

1. Engage stakeholders early.
2. Tailor measures to decisions to be made.
3. Consider data resources, availability, and tools.
4. Design communication devices.
5. Develop and document definitions and procedures.

**Project Development Process**

Thoroughfare designs are developed through a project development process. The project development process, as it applies to CSS, is described in Designing Walkable Urban Thoroughfares: A Context Sensitive Approach. Seven basic phases are identified:

1. Vision/goals.
4. Evaluation of alternatives.
5. Develop project plan/design.
6. Construction.
7. Operation and maintenance.

CSS has a role in each of these phases. Performance considerations are included in the previously cited references and others. The challenge in this task is to develop a framework that can address the needed considerations during (and after) project development to help agencies and other stakeholders understand and act appropriately based on actual or anticipated performance.

**Experience from Past Use of Performance Measures**

Performance measurement is not new. It has been used in alternatives analysis for nearly a half century. It has been used longer than that to describe and track transportation operations, safety, and maintenance. Hence, there is extensive experience in using performance measures. In continuing efforts to create more specific and responsive performance measurement systems, there is value to looking to past lessons using performance measurement. NCHRP Report 660, Transportation Performance Management: Insight From Practitioners, addresses experiences and insights related to the use of performance measurement.\(^{15}\)

One of the first insights is that it is not possible to develop a single, all-encompassing performance evaluation model that is applicable across everything a transportation agency does. This is also applicable for the 7 phases of project development. For example, visioning and maintenance have very different types of considerations. Hence, the desired performance

evaluation framework needed for this project may be based on a consistent set of objectives or interests but should be able to look at the different phases of project development in different ways.

Another insight discussed in NCHRP Report 660 is that the performance characteristics evaluated should align with customer expectations. Translating this into CSS terminology, performance measurement should address the vision, goals, objectives, and interests of the customers. Those customers vary by project and context. Hence, a set of measures for one project may not be applicable for another project. On the other hand, some project needs are consistent:

- There is usually a need to compare benefits and effects of different project alternatives.
- Transportation agencies usually have a need to justify the project in terms of quantifiable benefits, often in benefit/cost or cost-effectiveness forms.
- There is often a need to evaluate the longer term effects of the project to demonstrate long term benefits or other effects or longer term sufficiency of the project or system.
- Benefit assessment in the form of performance evaluation is regularly used in decision making and to decide where and when to make transportation improvements.

Additional insights applicable to CSS as applied for walkable urban thoroughfare design include:

- Address the most important or pressing goals, objectives and interests; those could involve the way the agency(s) conduct their (project related) business, the project, and/or context and could involve the process being used to reach a design or the expected outcomes.
- Understand and address causal factors and how they are linked to conditions or concerns that customers perceive and/or expect. Customer satisfaction along the way can be tracked using regular surveys.
- Focus on a limited number of goals, objectives, or interests – those which will or should drive decisions. Understand that excessive analysis or measurement gets in the way of decision making.
- Address existing and anticipated needs.
- Use performance measurement as a tool to aid decision making. It is not an end in itself.
- Keep performance measurement objective; do not include political influences or factors. Leave them external to the evaluation.
- Do not just report numbers or other indicators. Explain implications and relate them to the context, goals, etc.
- Remember the big picture and what is trying to be accomplished overall. This is a fundamental part of CSS.
- Make sure staff who develop and use performance measurement really understand it.

**PERFORMANCE MEASURE EXAMPLES**

There are numerous lists of performance measures that may be applied for a CSS project. Some examples are included in the appendix. However, many more could be adopted for uses associated with CSS and thoroughfare design. The characteristics of desired performance
measures should be determined as part of this task. They are described below in the framework section.

GETTING STARTED

Before starting to put together a set of performance measures, it is necessary to establish what the measures assessment is to accomplish and for whom. Purpose, scope, and audience all need to be known at the outset. Otherwise the performance measures selected may not respond to the needs.

To be able to design the performance measurement process and select measures, the following questions should be answered:

• What is the purpose of the assessment?
• What is to be assessed? Is it a process or practice? A project? Another kind of outcome?
• Who are the decision makers and what is their level of understanding of what is being assessed? Are there other audiences?
• What are their interests?
• What performance(s) can be reported about that will address their needs and interests?
• How straight-forward can we make the assessment? How much educating will be needed?

These and potentially other questions related to the purpose and audience(s) will need to be addressed before developing a performance measurement framework as described below. NCHRP Web Document 69 (previously referenced) has a section on getting started that may help.

FRAMEWORK: MEASURING CSS APPROACH FOR URBAN THOROUGHFARES

The desired framework should be able to accomplish the following:

• Measure performances of processes, outputs, and outcomes in any stage of project development.
• Support the desired application (e.g., describe, decision making) use of the performance measurement.
• Accept as input any relevant set of objectives for both project and related context, including any system or area effects associated with the project.
• Be achievable by typical transportation and planning agency technical staff.
• Require data that are available or reasonably collectable in a typical urban area.
• Be comprehensible to an average stakeholder and decision maker.
• Produce results that are sensitive to changes in the project and context.
• Require a modest amount of resources to complete.
• Establish targets or benchmarks to which the performance should be compared.

As mentioned previously, it is good practice to base an evaluation on the 6–8 most important objectives or issues. In some cases more will have to be considered. However, in such cases weighting can be used to incorporate relative importance into the process.
Table 8 shows how the performance measures could be organized for each phase of project development. For any single phase, objectives or issues would be the basis for the performance measurement. In most cases the objectives and corresponding measures would fall into just some of the cells.

Table 8. Organization of measures within each project development phase

<table>
<thead>
<tr>
<th>Applicability</th>
<th>Type of Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Process</td>
</tr>
<tr>
<td>Agency</td>
<td>Objective 1:</td>
</tr>
<tr>
<td></td>
<td>Objective 2:</td>
</tr>
<tr>
<td>Project</td>
<td>Network Effects</td>
</tr>
<tr>
<td></td>
<td>Facility</td>
</tr>
<tr>
<td>Context</td>
<td></td>
</tr>
</tbody>
</table>

For example, in the first phase of project development—developing a vision and goals—one objective would probably be to establish a stakeholder involvement process to obtain input on vision including objectives, issues, and opportunities. That would be an agency process objective. Specific wording would lead to the performance measure that might be the number or percentage of identified stakeholders who became (meaningfully) involved. There might also be objectives related to outputs (e.g., number of stakeholder work sessions) or outcomes (the number of stakeholders who provided the requested or meaningful output, or the number of interest groups that endorsed the vision and objectives).

In this phase there might not be many objectives in the project or context categories. However, in the needs assessment there certainly would be objectives for both project and context rows since this is where the project-related needs and objectives would be refined in accordance with a technical and policy analysis.

Table 9 shows a more complete example of a matrix. It contains the objectives or considerations that could be included in a performance assessment. This example is for the project planning and design phase of project development. It provides examples of many more objectives or interests than would ever be used in one performance assessment. This example is to show a range of possibilities, not a specific project example.
Table 9. Examples of objectives/interests that might be considered for project plan and design evaluation (sample measures not shown)

<table>
<thead>
<tr>
<th>Applicability</th>
<th>Process</th>
<th>Type of Result</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agency</strong></td>
<td>Multidisciplinary design team</td>
<td>Project delivery (schedule, cost)</td>
<td>Approved/accepted project</td>
</tr>
<tr>
<td></td>
<td>Communications</td>
<td>Project cost</td>
<td>Stakeholder satisfaction with process</td>
</tr>
<tr>
<td></td>
<td>Consensus building</td>
<td>Communications</td>
<td>Project cost within budget</td>
</tr>
<tr>
<td></td>
<td>Achievement of objectives, commitments</td>
<td>Interaction/coordination/collaboration events</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value engineering</td>
<td>Environmental stewardship</td>
<td></td>
</tr>
<tr>
<td><strong>Network Effects</strong></td>
<td>Design changes to accommodate project facility changes</td>
<td>Network operational sufficiency (mobility – all modes)</td>
<td>Network operation</td>
</tr>
<tr>
<td></td>
<td>Verify sufficient network operation</td>
<td>Network improvements</td>
<td></td>
</tr>
<tr>
<td><strong>Project Facility</strong></td>
<td>Operational analysis</td>
<td>Quality of service by mode</td>
<td>Increased mobility options</td>
</tr>
<tr>
<td></td>
<td>Accommodate objectives (e.g., travelway, streetside, integration with context, intersections, accessibility, aesthetics, etc.)</td>
<td>Design features (e.g., pavement, lighting, crossing frequency, target speed, streetscape, etc.)</td>
<td>Resulting quality of service (pedestrians, bikes, transit, motor vehicles, goods movement)</td>
</tr>
<tr>
<td></td>
<td>Design flexibility</td>
<td>Safety features (all modes)</td>
<td>Stakeholder satisfaction with facility design</td>
</tr>
<tr>
<td></td>
<td>Road safety audit</td>
<td>Construction phasing, disruption mitigation</td>
<td>Aesthetics</td>
</tr>
<tr>
<td><strong>Context</strong></td>
<td>Understand context</td>
<td>Interface design (thoroughfare-adjacent properties)</td>
<td>Stakeholder satisfaction with support/changes in context</td>
</tr>
<tr>
<td></td>
<td>Coordination (utilities, adjacent sites/buildings and improvements, transit, etc.)</td>
<td>Environmental mitigation</td>
<td>Environmental harmony</td>
</tr>
<tr>
<td></td>
<td>Environmental harmony</td>
<td>Economic development support/accommodation</td>
<td>Integration with adjacent buildings</td>
</tr>
<tr>
<td></td>
<td>Economic development</td>
<td></td>
<td>Complementary urban design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Economic development</td>
</tr>
</tbody>
</table>

Keep in mind that only objectives/considerations that are relevant to sponsor and stakeholder interests would be employed in an evaluation. Even though this example contains numerous different objectives and interests, it is still just a very small cross-section of all of the potential objectives/considerations that could be selected by an agency and its collaborators as being of interest.

It is conceivable that an agency would want to conduct a different type of evaluation for its internal operations than for projects. That is expected and could be supported by the framework. After all, the framework is merely an organizational tool to store performance measures and to see what combinations of application and measure type are being used or proposed.
Figure 1 shows steps that could be used to develop a performance evaluation for any phase of project development. It develops the output needs first, then the associated objectives, issues, or other interests for which the evaluation would need to assess performance. This approach is beneficial because it starts by considering the “customer” needs first rather than selecting performance measures and finding that they do not satisfy customer, technical, and communications needs.

Once the application (first box) is determined and the project development stage for which the performance assessment is being done is determined (second box), the project or facility objectives, issues, and interests are determined (third box down). This usually is determined from input from stakeholders, elected officials, interdisciplinary team members, members of the public, and relevant others. Those objectives, issues, and interests are organized using CSS strategies and principles.
strategies and principles and qualities (box entering from right). Once the objectives, issues, and interests have been established the selection of performance measures can begin.

In general, a performance measure should directly quantify the performance of a project or facility (or context) related to the objective, issue, or interest. For example, if a project objective was to facilitate pedestrian crossings of a thoroughfare, an appropriate measure could quantify the ease in terms of crossing distance or distance between marked or signalized crossings.

**Conventional Measures Approach**

The conventional approach to performance evaluation has been for the interdisciplinary project team to select performance measures that correspond to project objectives, issues, and interest. The public involvement participants often review the measures and accept them or suggest additional or alternative measures. The interdisciplinary team then estimates performance for each measure. If a measure involves a polling of the participants, that can also be done using objective questions. The participants then usually review the results. Sometimes the measures are weighted to reflect consensus priorities of each corresponding object, issue, or interest.

Once the performance estimates and weights have been determined, results are compiled. The performance assessment may compare outcomes to goals or may compare project alternatives. In either case the participants may choose to draw conclusions based on the results or may consider re-weighting the measures or conducting a sensitivity analysis to see if variations in weights or performance would cause an appreciable change in the results. In the end, the resulting scores would be used by the interdisciplinary team and sponsoring agency(s) to guide further actions.

Table 9 presented examples of objectives or interests that might be considered during the planning/design phase of project development. Tables 10–13 display sample performance measures for each of the entries in Table 9 as follows:

- Table 10: measures for Agency row of Table 9.
- Table 11: measures for Project-Network Effects row of Table 9.
- Table 12: measures for Project-Facility row of Table 9.
- Table 13: measures for Context row of Table 9.

Tables 10–13 also include references to the CSS core principles, qualities, and outcomes that are listed earlier in this document. The numbers next to each objective or interest listed in those tables correspond to the numbers of listed principles, qualities, and outcomes. These references help keep the performance measures consistent with CSS.

Readers should keep two things in mind when looking at Tables 10–13:

- These are but a very few of the objectives and corresponding measures that could be used in this or any phase of project development.
- Measures must quantify directly how well the facility or project does or will perform relative to the objective or interest.

Several of the references cited early in this document describe the science and art of selecting applicable performance measures.
Table 10. Examples of Performance Measures That Could Be Used – Planning/Design Phase of a CSS Project – *Agency Level Applications*¹

<table>
<thead>
<tr>
<th>Applicability</th>
<th>PROCESS Type of Results/Sample Measures</th>
<th>CSS OUTPUTS Type of Results/Sample Measures</th>
<th>CSS OUTPUTS Type of Results/Sample Measures</th>
<th>CSS OUTPUTS Type of Results/Sample Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary design team</td>
<td>4 1 1</td>
<td>Project delivery</td>
<td>10 5</td>
<td>Approved/accepted projects</td>
</tr>
<tr>
<td></td>
<td><em>Average number per project of separate relevant disciplines with confirmed expertise</em></td>
<td><em>Percent of project plan/design phases completed within original schedule</em></td>
<td><em>Percent of projects with design and NEPA approval/acceptance without significant (define) rework of design</em></td>
<td><em>Percent of designs approved by partner agencies within __ months of design completion.</em></td>
</tr>
<tr>
<td></td>
<td><em>Average percentage of applicable disciplines represented by senior experts</em></td>
<td><em>Percent of projects with plan/design phases completed within __ % of original phase budget</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communications</td>
<td>3 3 12</td>
<td>Project cost</td>
<td>10 5</td>
<td>Stakeholder satisfaction with process</td>
</tr>
<tr>
<td></td>
<td><em>Average number of types of project communications implemented for projects</em></td>
<td><em>Percent of projects meeting original plan/design phase budgets</em></td>
<td><em>Percent of projects in which stakeholder surveys indicate consensus (define in advance)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Average communication frequency (per year) meeting established criteria</em></td>
<td><em>Percent of cost increase due to design scope changes during plan/design phase</em></td>
<td><em>Percent of projects that plan/design phase proceeds to completion without significant revision of process or design rework</em></td>
<td></td>
</tr>
<tr>
<td>Consensus building</td>
<td>1 3 7 8 3</td>
<td>Communications</td>
<td>3 3 12</td>
<td>Project cost within budget</td>
</tr>
<tr>
<td></td>
<td><em>Percent of projects with project development process approved by local leaders</em></td>
<td><em>Average frequency of specified types of project communication</em></td>
<td><em>Average percent of cost overrun compared to original project budget</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Percent of projects with collaborative process to reach stakeholder consensus</em></td>
<td><em>Percent of projects that use websites to collect stakeholder and public input that is used.</em></td>
<td><em>Percent of projects with implementation cost exceeding __% of original budget</em></td>
<td></td>
</tr>
<tr>
<td>Achievement of objectives</td>
<td>1 4 9 3</td>
<td>Interaction/coordination/collaboration</td>
<td>10 4 5</td>
<td>Additional (context) value created</td>
</tr>
<tr>
<td></td>
<td><em>Percentage of projects for which objectives/commitments are pursued during the plan/design phase</em></td>
<td><em>Percent of projects including stakeholder satisfaction surveys during plan/design phase</em></td>
<td><em>Average increase in assessed valuation as percentage of project cost (define base and assessment year)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Percentage of projects in which abutting parcels are to benefit in desired manner</em></td>
<td><em>Average frequency of full-scale (define) coordination meetings among partner agencies</em></td>
<td><em>Percent of projects for which value added assessment is completed</em></td>
<td></td>
</tr>
<tr>
<td>Value engineering</td>
<td>4 10 5</td>
<td>Environmental stewardship</td>
<td>4 7 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Percent of projects having value engineering during plan/development phase</em></td>
<td><em>Percent of projects completing NEPA process or equivalent</em></td>
<td><em>Percent of projects incorporating biofiltration of stormwater</em></td>
<td></td>
</tr>
</tbody>
</table>

¹ Column legend: P = CSS core principle number; Q = quality number; O = outcome number; see p. 2–3 for descriptions. An entry of “S” indicates support for other outcomes.
Table 11. Examples of Performance Measures That Could Be Used – Planning/Design Phase of a CSS Project – *Project/Network Effects Applications*¹

<table>
<thead>
<tr>
<th>Applicability</th>
<th>Process/Type of Results/Sample Measures</th>
<th>Output 1</th>
<th>CSS</th>
<th>Output 2</th>
<th>CSS</th>
<th>Output 3</th>
<th>CSS</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Effects</td>
<td>Design changes to accommodate project facility changes</td>
<td>4</td>
<td>9</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Percent of needed associated network changes included in or parallel to the current project design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Percent of needed associated network changes funded in conjunction with current project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Verify sufficient network operation</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Area/region network tested for network operations sufficiency as part of project plan (yes/no)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Percent of area/region network analyzed for operational efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Column legend: P = CSS core principle number; Q = quality number; O = outcome number; see p. 2–3 for descriptions. An entry of “S” indicates support for other outcomes.
Table 12. Examples of Performance Measures That Could Be Used – Planning/Design Phase of a CSS Project – *Project/Facility Applications*

<table>
<thead>
<tr>
<th>Applicability</th>
<th>PROCESS Type of Results/Sample Measures</th>
<th>CSS Outputs Type of Results/Sample Measures</th>
<th>OUTCOMES Type of Results/Sample Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational analysis</td>
<td>% of modes for which operational analyses are completed</td>
<td>Estimated volume/capacity by mode</td>
<td>Average number modes for which specific facilities (define) are provided per block</td>
</tr>
<tr>
<td></td>
<td>Level of sophistication (define) of modal operational analyses (e.g., connectivity, LOS, quality of service)</td>
<td>Multimodal quality of service</td>
<td>Average pedestrian crossing times – major thoroughfares</td>
</tr>
<tr>
<td>Accommodate objectives</td>
<td>% of stakeholder objectives included in adopted project objectives</td>
<td>Number of separate locations with walkable features (e.g., curb extensions, bus shelters, bike lanes, signalized crosswalks)</td>
<td>Multimodal quality of service</td>
</tr>
<tr>
<td></td>
<td>% of stakeholder interest categories represented in adopted project objectives</td>
<td>% of blocks with 400 feet or less between crosswalks</td>
<td>% of pedestrian throughway length to be shaded by street trees or overhead structures 5 years after project completion</td>
</tr>
<tr>
<td>Design flexibility</td>
<td>% of different alternatives examined</td>
<td>% of blocks with at least feet between traffic lanes and ped. thoroughway</td>
<td>Level of satisfaction based on survey after review of final design and visualizations</td>
</tr>
<tr>
<td></td>
<td>Required degree of compliance with agency of jurisdiction design standards (e.g., complete, design exceptions permitted, ITE RP or higher, none)</td>
<td>Average distance along major thoroughfares between signalized crosswalks</td>
<td>% of stakeholders satisfied with design based on responses at final public meeting to discuss design</td>
</tr>
<tr>
<td>Road safety audit</td>
<td>% of plan/design phases including road safety audit (concept design, preliminary design, final design, etc.)</td>
<td>Average duration of construction per block</td>
<td>Percent of blocks containing desired aesthetic design features (define) (e.g., special street hardware, trees, street furniture, etc.)</td>
</tr>
<tr>
<td></td>
<td>% of items included in road safety audit (e.g., modes, travelled way, street-side interface with abutting bldgs, etc.)</td>
<td>Average duration of temporary sidewalks serving abutting businesses</td>
<td>Level of satisfaction based on survey after review of final design and visualizations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety and security</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average percent of required sight distance available at crosswalk locations</td>
<td>Percent of block length containing pedestrian sight obstructions not meeting CPTED2 sight line guidelines</td>
<td></td>
</tr>
</tbody>
</table>

1. Column legend: P = CSS core principle number; Q = quality number; O = outcome number; see p. 2–3 for descriptions. An entry of “S” indicates support for other outcomes.
2. CPTED – Crime Prevention Through Environmental Design.
Table 13. Examples of Performance Measures That Could Be Used – Planning/Design Phase of a CSS Project – *Context Applications*¹

<table>
<thead>
<tr>
<th>Applicability</th>
<th>PROCESS Type of Results/Sample Measures</th>
<th>CSS Type of Results/Sample Measures</th>
<th>OUTPUTS Type of Results/Sample Measures</th>
<th>OUTCOMES Type of Results/Sample Measures</th>
<th>CSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand context</td>
<td>2 2 1 Interface design (w/ adjacent properties)</td>
<td>4 8 1 Stakeholder satisfaction with context changes</td>
<td>Percent of stakeholders satisfied (based on survey questions) with changes in context resulting from project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percent of abutting business owner/managers that have been interviewed regarding needs, objectives, issues, opportunities regarding project and their businesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Percent of context-oriented multidisciplinary analyses (define) completed</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Coordination (utilities, adjacent bldgs)</td>
<td>3 6 3 Environmental mitigation</td>
<td>4 7 4 Environmental harmony</td>
<td>Percent of potentially adverse impacts that will be fully mitigated (define) by project design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Time required/lost after completion of final design to obtain utility (and other) relocation plans approval and funding (e.g., meetings per year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Full coordination meeting frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental harmony</td>
<td>4 7 4 Economic development support</td>
<td>4 9 3 Integration with adjacent buildings</td>
<td>Percent of stakeholders satisfied (based on survey) with project support for context objectives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percentage of environmental factors to be analyzed under existing conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Level of commitment of partner agencies to achieve harmony and improvement (e.g., avoid, mitigate, improve)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percentage of project frontage abutting desired development/redevelopment, vacant bldgs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percent of project cost adjacent to desired development/redevelopment, vacant bldgs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complementary urban design</td>
<td>4 8 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percent of building entrances opposite which project design provides compatible or supportive (define) features</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic development</td>
<td>4 9 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percent of frontage slated for development/redevelopment provided with full project treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Number of MOAs signed for partnered project improvements involving buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added</td>
<td>1 11 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Estimated increase in valuation of parcels adjacent to project that will result from project design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Square feet of space made available for dining in project right of way</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Column legend: P = CSS core principle number; Q = quality number; O = outcome number; see p. 2
The appendices of this document contain lists of performance measures that could be considered for various aspects of performance of a transportation facility, project, or process. These lists provide a large number of measures, but the potential list of additional measures is almost limitless because the potential for differing objectives and interests is almost limitless.

**Direct Participant Quantification**

Another approach to measuring performance of the CSS process and outcomes uses a more direct method of acquiring measurement from stakeholders, interdisciplinary team members, and others with interest. This approach obtains the participants’ views of how well the process has worked and to what extent the projects goals, objectives, and issues have been and achieved and addressed. The essential ingredients for this approach are appropriate representation of participants (stakeholders, interdisciplinary team members, and other interested parties) and a set of questions that will both cover the key objectives, processes, and outcomes and result in unbiased responses.

**Three Components**

Three components are necessary for this approach to work well:
- Appropriate participants.
- Relevant unbiased questions (that form the basis for the performance measures).
- Applicable rating system.

**Participants**

As mentioned above, the three categories of appropriate participants are:
- **Stakeholder Group(s).** Any parties affected by or having an interest in affecting the project. These may include community residents, business people, environmental and civic groups and individuals, as well as project funding partners, reviewing and regulatory agencies, and elected officials and decision makers who choose to be actively involved in the work of stakeholders. That work would usually include at least setting a vision and goals for the project as well as identifying and considering relevant issues, opportunities, and alternatives to make the project successful for its users and the community.
- **Interdisciplinary Team.** The technical and management members of the project’s agency(s) of jurisdiction as well as representatives of the various disciplines involved in conceptualizing, developing, analyzing, and designing the project and its interaction with the project context. The interdisciplinary team may also include actively involved technical staff from cooperating agencies involved in the financing, review, and regulatory aspects of the project.
- **Parties of Interest.** Parties with an interest in the project who are not actively engaged in its development as stakeholders or interdisciplinary team members. These may include elected and appointed officials and decision makers, representatives of agencies, other interested groups and individuals, and the media.
These participants are either actively involved in setting goals and objectives for the project, identifying relevant issues, opportunities and alternatives to be considered, or at least have an interest in the process of developing the project, as well as the outcome. There are no better sources of information and feedback in evaluating the performance of the CSS process and its outcomes.

**Questions as the Basis for Performance Measurement**

The second component of this approach is a set of questions that is used to ascertain from the participants how well the CSS process worked and how well the project outcomes (including anticipated benefits and impacts on the community) have met expectations. There are two subsets of questions:

- **Core questions** – universally applicable to all projects these questions ask how well the CSS process worked and how well in general the outcomes met expectations.
- **Additional questions** – specific to a given project, these questions ask how well the project outcomes met expectations specific to a given project.

Every question must be carefully shaped by competent opinion survey researchers so it objectively captures the process or outcome component being assessed. Poorly worded questions can introduce bias and confusion and make the input unreliable and therefore useless.

The subject of the questions should address the key aspects of the project development process and the outcomes as they relate to the phase of project development being evaluated. One set of questions may be relevant if the performance evaluation occurs after the project concept has been developed. After completion of construction and initial operations some questions may change and some may be the same. However, all questions should be carefully designed to objectively determine how well the process and project met goals and expectations.

Topics that would normally be among the core questions include but are not limited to how well expectations were met for:

- Degree to which full breadth of stakeholders were involved and encouraged to stay involved.
- Degree to which an interdisciplinary team representing all relevant technical aspects was focused primarily on creating an excellent project outcome (as opposed to focusing primarily on the interests of the individual disciplines).
- Meaningful interaction among participants (particularly stakeholders and interdisciplinary team) in the project development process.
- Use of full range of communications strategies to encourage and support broad involvement.
- Thoughtful consideration of participant input.
- Efforts by sponsors to make project and process understandable to participants.
- Achievement of consensus on purpose and need.
- Participant trust in process and agency(s).
- Consideration of appropriate transportation modes and users.
- Consideration of community and social issues.
- Environmental stewardship.
Consider a full range of design choices appropriate to the context.

- Thorough understanding and consideration of objectives and issues related to area surrounding project and its activities (i.e., project context).
- Logical, fair, and transparent decision process considering input from participants.
- Tracking and meeting all commitments and document project decisions.
- Project performance outcomes, such as operation, safety, mobility (by mode), appearance, service to users, effects on adjacent activities, create lasting value for the community, support for other objectives, quality of life, etc. (normally includes different questions for different aspects associated with project objectives or issues).

In a few cases the attribute to be measured may be an operational or other technical measure. One example is traffic operating speed in relation to target speed; Tables 10–13 contain other examples. The performance of such measures would be gathered using a technical survey rather than by opinion poll. However, it would be considered with the opinion poll questions.

**Applicable Rating System**

Normally these questions become the basis for the performance evaluation. The questions are administered in survey form to all participants who have been regularly involved. Responses are on a scale (e.g., range of 0–10) of how well the questioned aspect met expectations as discussed in participant work sessions. Any directly measured project attribute (e.g., traffic operating speed) would be determined separately but considered with the opinion poll questions. As with the other approach, questions can be weighted according to importance.

It is critical that this input be obtained in a manner that will not result in bias or be affected by uninformed input. Hence, the method of gathering input needs to be carefully considered. Input should be sought only from those who have participated regularly in or have a direct interest in the process and its outcomes. Input should be provided on an individual basis (e.g., a questionnaire responded to during a project work session).

**Developing This Approach**

Selection of participants and the opinion poll questions are critical to the success of this approach. Parties of interest who have not actively participated in or directly observed the CSS process may be asked a portion of questions focusing on outcomes as opposed to the process itself. “Screening” questions would be used to determine whether a person has had sufficient involvement to comment on the process. “Screening” questions would be used to determine whether a person has had sufficient involvement to comment on the process.

The participants providing feedback for performance evaluation need to be genuinely interested in providing constructive input. A simple set of criteria should be developed for selecting participants who will provide input for performance measurement. This can be done by a person who is highly experienced in public involvement for transportation. It should be clear, however, that the criteria should not be used to limit public participation in the project.

The core set of questions could best be developed by a national panel of people with extensive public involvement experience in transportation project development using the CSS process. The questions themselves should be written by an opinion polling expert. These questions would be
universally applicable to all projects. A sample set of potential project specific questions could also be developed to serve as a model for the additional, non-core questions.

For a specific project, the “additional” questions selected would correspond to the project’s own objectives and issues. A project could have an objective or issue that might require a question not already on the resource list. That question would need to be worded by an experienced opinion survey expert to ensure clarity, objectivity, and freedom from bias.

**STEPS TO COMPLETE WALKABLE CSS THOROUGHFARE PERFORMANCE MEASUREMENT SYSTEM**

The following is a proposed scope of work to develop a full performance measurement system for walkable thoroughfares. This system would flesh out a fuller range of objectives and interests for the planning/design phase of project development, but would also do the same for the other six phases of project development. This would cover agency, project, and context considerations from early visioning through project development to operation and maintenance. The work scope would also include a concise user guide and could provide an online spreadsheet tool for compiling performance assessments.

**Purpose**

Provide a performance measurement system to assess the performance of transportation agency, project, and context from the perspective of process, outputs, and outcomes for walkable thoroughfares designed using CSS. The system should be able to use the conventional and direct participant quantification methods.

**Desired Deliverables**

- Report describing the process to properly develop performance measures for the two types of quantification.
- The performance measurement framework, which may be as shown in Figure 1 or a refinement thereof.
- A set of core questions covering typical aspects of CSS process and project outcomes for direct participant quantification of project performance.
- The most frequently used or likely objectives and interests (such as the examples shown in Figure 9) for each of the twelve cells of the Figure 9 matrix and for each of the seven phases of project development shown in the second box of Figure 1.
- An average of at least three performance measures for each objective or interest listed; it is understood that some objectives/interests may have fewer and some more. It is also understood that some cells could have no entries.
- A user guide on how to use the system.
- A spreadsheet that can accommodate either measures included in the project report or others inserted by users, and which will compute performance based on inputs. This spreadsheet will not compute performances, but it will tabulate combined performance based on input performances and weighting of measures according to input weights.
Anticipated Work Tasks

1. Identify 5–10 practitioners to serve as a peer review panel. Introduce them to the project as the work scope is being finalized so they can provide input regarding needs as the project is initiated.

2. Select a national panel of CSS experts who will create the set of core CSS process and outcome questions to be used for direct participant quantification.

3. Kick off project with a meeting/tele/videoconference to discuss project objects, scope, and deliverables as well as details of how the project will be done. Refine work scope as needed.

4. Review this memorandum plus the referenced source documents listed in the text or bibliography. Search internet for references completed since January 2011 when bibliography was assembled. Summarize relevant findings.

5. Refine Figure 1 framework as appropriate to cover all seven phases of project development and to address agency, project, and context objectives and interests by process, outputs, and outcomes as shown in Figure 8. Provide a written description of process and steps and review with project sponsor. Refine further as appropriate.

6. Develop a comprehensive list of frequent objectives that would fit into each cell of the framework matrix (Figure 8) for each project development phase. Each cell should contain a minimum of three objectives/interests unless justified. Review with project sponsor, then refine as appropriate.

7. Convene national CSS expert panel to develop set of core process and outcome question content.

8. Conduct teleconference to have CSS expert panel review core question content with review panel and project management team; revise questions as appropriate.

9. Have opinion poll expert word each core question for objectivity without bias.

10. For each of the objectives in subtask 6, develop at least three performance measures. Complete for all 12 cells of the matrix for each of the seven phases of project development. Review each measure to confirm that necessary data will normally be easily available, collected, or created using commonly available data and/or procedures.

11. Identify likely data source for each measure. Eliminate and replace those for which data are likely to be infrequently available or difficult or expensive to obtain or estimate.

12. Synthesize from source documents how best to weight performance measures. More than one approach may be viable, and if so, document basis for selecting a method.

13. Develop a flow chart that would be used to develop a spreadsheet tool for compiling performances. At a minimum, the tool should include:
   a. Ability to weight measures individually, but then to compile composite/combined performances.
   b. Input performances for each measure (but no internal computations of performance from raw data).
   c. Graphic outputs showing both individual and composite performances using selected measures.
   d. User-friendly spreadsheet for inputs and outputs.

14. Review with project sponsor and project panel and refine as appropriate.

15. Develop spreadsheet tool and test with examples to ensure that spreadsheet outputs match separately computed outputs.

16. Adapt spreadsheet for online use and confirm its proper operation.
17. Prepare concise but complete, uncomplicated user guide. Submit to project sponsor and project panel for review. Refine as needed.
18. Prepare draft report describing project findings, tools, and recommendations regarding use. Submit to project sponsor and project panel for review.
19. Review comments received and make changes as needed.
20. Install online spreadsheet on sponsor’s or other designated server. The sponsor will secure permission to use that server and pay any costs for its use as the tool’s website.

**Estimated Order of Magnitude Cost**

The basic work included in the work scope could be completed for a range of $100,000 to $120,000. The specific cost will vary depending on how the measures are developed, details of deliverables, extent of collaboration with other entities, review process, and the capabilities desired in the user guide and the online spreadsheet tool.
BIBLIOGRAPHY

Performance Measures for CSS in the Design of Walkable Urban Thoroughfares

The following resources have been identified as sources for relevant material regarding background, structures, applications, and measures for use in developing performance measures for use using the CSS approach for planning and design of walkable urban thoroughfares. Additional sources are available that describe the general use of performance measures and other uses and applications within transportation agencies.

Additional references may be added if found while working to complete this task.

9. Cambridge Systematics, Dowling Associates, System Metrics Group, and Texas Transportation Institute, Cost-Effective Performance Measures for Time and Delay,


38. Texas Transportation Institute, Cambridge Systematics, CH2M Hill, Hill Street Consulting Group, Henrick Gudmunsson, Ralph Hall, and Gregory Marsden, *Sustainability Performance Measures for State DOTs and Other Transportation Agencies*, Interim Report, NCHRP Project 8-74, Texas Transportation Institute, College Station, Texas, October 2010.


APPENDICES
Appendix A. Transportation-Related Performance Measures – Sustainability

From Developing Sustainable Transportation Performance Measures for TxDOT’s Strategic Plan, Technical Report 0-5541-1, Texas Transportation Institute, April 2009.

This report provided a long list of quantitative performance measures covering a number of different aspects related to CSS. The following could be of interest in an assessment of walkable thoroughfares planned and designed using CSS:

**Accessibility**
- Average trip length
- Accessibility index
- Percent work trips within specific travel time
- Percent labor force within specified distances of job location(s)
- Percentage of employment sites within x miles of major highway
- Percentage of population within x minutes of y percentage of employment sites
- Percentage of region’s mobility impaired who can reach specific activities by public transportation

**Intercity travel time**
- Peak-hour average travel speeds on major highway routes between regional centers
- Shipper point-to-point travel time

**Freight travel time to global markets**
- Travel time to major regional, national, and global markets by rail, air, water, and truck
- Connectivity to intermodal facilities (% within 5 miles [1 mile for metropolitan])
- Connectivity index (by week)
- Dwelling unit proximity (% within 5 miles [1 mile for metropolitan])
- Employment proximity (% within 5 miles [1 mile for metropolitan])
- Industrial and warehouse facility proximity (% within 5 miles)
- % of miles bicycle accommodations (% of miles with bike lane/shoulder coverage)
- % of miles pedestrian accommodations (% of miles with sidewalk coverage)
- Coverage (percentage of person minutes served)
- Frequency (buses per hour)
- Span (hours of service per day)
- VMT per capita
- Average work trip commute time and distance
- Parking spaces per 1,000 workers
- Transit availability and affordability

**Mobility**
- Average speed or travel time
- Commute cost
- Commute time
- Short trips made by auto
- Per capita VMT
- Vehicle miles traveled by congestion level
- Lost time or delay due to congestion
- Delay per ton-mile
- Level of service or volume-to-capacity ratios
- Vehicle hours traveled or VMT per capita
- Person-hours traveled
- Person-miles traveled per VMT
- PMT per capita or worker
- Frequency of transit service
- Overall mode split by facility or route
- Transfer time between modes
- Passenger trips per household
- Peak hour occupancy
- Light duty/2-wheel vehicles
- Percentage of low emission vehicles
- Percent walking or using bike by trip type
- Predictable, competitive metro-area travel time
- Metro freeway travel time by route and time of day
- Average speed on metro freeways by route and time of day
- Congestion level compared with other major metropolitan areas

**Bottlenecks and impediments**
- Number of design impediments to freight traffic by mode and type (at-grade rail crossings, restricted roads, deficient bridges, etc.)

**Timely access to intermodal terminals**
- Number of design impediments slowing access to truck, rail, air, waterways terminals

**Quality of service (transit)**
- Average speed
- Average headway (minutes)
- Average age of fleet (years)
- Number of incidents
- Revenue service interruptions
- Revenue miles between incidents
- Revenue miles between interruptions
- Ridership and customer services (complaints and commendations per 1,000 passengers)

**Quality of travel**
- Average speed (average speed weighted by PMT)
- Delay (average delay)
- Average travel time (distance/speed)
- Average trip time (door-to-door trip travel time)
- Reliability (% of acceptable travel times)
  - Maneuverability (vehicles per hour per lane)
- Auto to transit travel time ratio (door-to-door trip time)
- Reliability (on-time performance)

- System Utilization
  - % of system heavily congested (% of miles at LOS [level of service] E or F)
  - % of travel heavily congested (% of daily VMT at LOS E or F)
  - Vehicles per lane mile (AADT[annual average daily traffic] *length/lane-miles)
  - Duration of congestion (lane-mile-hours at LOS E or F)
  - Load factor (percentage of seats occupied)

- Non-auto mode split
- Non-auto trips
- Transit speed relative to auto
- Service miles of transit
- Miles of separate bikeways
- Reliability
  - Probability that users will arrive at destinations on time
  - Emergency medical response time

**Economic Development**

- Population
- GDP (GDP/Unit of Energy Used)
- Green GDP
- Transportation Intensity (passengers or ton-miles per unit GDP)
- Percentage of wholesale, retail, and commercial centers served with unrestricted (vehicle) weight roads
- Jobs created or supported (directly or indirectly)
- Percentage of region’s unemployed or low income that cite transportation access as principle barrier to seeking employment
- Tax base increase (property tax)
- Sales tax increase
- Change in property value
- New jobs created
- New construction jobs created
- New wages/revenues created
- Employment
- Employment to population ratio in central areas
- Tax revenues
- Public expenditure
- Growth potential
- Fuel prices and tax collection from fuel
- Overall expenditure on roads and transit

**Economics/Costs**

- Economic cost of crashes
- Economic cost of lost time
- Real change in the cost of transport
- Cost-benefit measures
- Average cost per lane-mile constructed

**Economic cost-benefit ratio**
- Cost-benefit ratio of major state transportation projects

**Transportation investment**
- State’s transportation investment and spending as percentage of gross state product

**Competitiveness of shipping rates**
- Shipment cost per mile by ton or value by mode for major commodities

**Crash rate and cost comparison**
- Dollar value of crashes and crash cost comparison by mode
- Crash rate per mile traveled (or other basis) by freight mode

**Cost efficiency**
- Operating expenses per capita
- Operating expenses per peak vehicle
- Operating expenses per passenger trip
- Operating expenses per passenger mile
- Operating expenses per vehicle mile
- Operating expenses per revenue mile
- Operating expenses per revenue hour
- Maintenance expenses per revenue mile
- Maintenance expenses per operating expenses
- Maintenance expenses as percentage of operating expenses or agency budget
- Cost of travel time saved
- Operating cost saved

**Operating ratios (transit)**
- Farebox recovery
- Local revenue per operating expenses
- Operating revenue per operating expenses

**Fare collection**
- Fare receipts versus budget
- Fare recovery ratio
- Operating subsidy per passenger trip
- Average fare per passenger trip

**Finance (budget)**
- Operating expenses: actual versus budget by line item, capital expenses by project, by grant, by general ledger number
- Revenues: actual versus budget
- Cost recovery for transit
- Annual ridership
- Aircraft departures

**Environmental Resource Consumption and Depletion**
- Fuel consumption per VMT or PMT
- Sprawl
  - Difference between change in urban household density and suburban household density
  - Percentage of land occupied by developed parcels
  - Acres/percentage of formerly agricultural/open land lost to urbanization
  - Percentage greenfield development
  - Percentage development on urban fringe
- Wetlands displaced
- Wetlands created
- Loss or segregation of fauna habitat
- Agricultural land
- Agricultural land at urban fringe
- Green space per capita
- Percentage of urban redevelopment
- Number of transit-oriented developments
- Percentage of development that is infill
- Percentage development that is redevelopment
- Density of population and employment

**Environmental Quality and Impacts**
- Tons of pollution
- Number of days in air quality noncompliance
- Number of good air days
- Tons of waste per household
- Total water consumption
- Energy consumed
- Quality of water in rivers
- Biodiversity
- Area of greenfield sites
- Energy use and air quality
  - Total energy use per capita
  - Energy cost per dollar output
  - Proportion of alternative fuels
  - Total pollutant emissions per capita
  - Total greenhouse gas emissions (or emission of CO, CO₂, ozone, NOₓ, VOCs, hydrocarbon, SO₂)
  - Days meeting air standards
  - Average fuel consumption
  - Vehicles failing emissions test
  - Household noise complaints
  - Black smoke emissions
- Water, materials, and waste
- Total water use per capita
- Days meeting quality standards
- Sewage treated to reusable standards
- Sewage discharged to streams
- Consumption of building materials
- Consumption of paper and packaging
- Amount of solid waste
- Organic waste returned to soil

- Number of noise-sensitive sites potentially affected
- Length of noise wall required
- Developable areas subjected to unacceptable noise level
- Land reclaimed

**Air quality**
- Air pollution concentrations
- Emissions per capita
- Acute respiratory deaths

**Water quality**
- Percentage of wastewater treated
- Percentage of BOD (biological oxygen demand) removed
- Treatment cost
- Lowering of water table
- Wastewater recycled
- Level of treatment

**Energy use**
- Energy use per person
- Renewable energy use
- Neighborhoods impacted
- Number of hospitals impacted
- Number of schools/students impacted
- Number of churches impacted
- Number of accidents involving hazardous waste
- Alternative fuels used
- Toxic substances in urban air
- Oil spills
- Incidents involving hazardous material
- Investments dedicated to environmental protection

**Safety**
- Number of accidents per VMT, PMT, year, trip, ton-mile, and capita
- Cost of accidents
- Cost of collisions
- Number of high accident locations
- Response time to accidents
- Accident risk index
- Customer perception of safety
- Percentage of roadway pavement rated good or better
- Construction-related fatalities
- Accidents at major intermodal locations (e.g., railroad crossings)
- Pedestrian-bicycle accidents
- Crashes per 1,000 people

Quality of Life
- Lost time due to congestion
- Accidents per VMT or PMT
- Tons of pollution generated
- Customer perception of safety
- Customer perception of urban quality
- Average number of hours spent traveling – non-recreational travel
- Percentage of population exposed to noise above certain threshold
- Compatibility with adjacent development
- Delivery services and transit facilities for mobility impaired
- % HH expenditure on transportation

Livability and Social Development
- Miles of pedestrian-friendly streets
- Mixed land use
- Inequity of user costs and benefits
- Areas above a certain value not separated by a motorway
- Residents participation in decision-making
- Customer perception of quality
- ADA requirements conformance
- Percentage of travel in congested conditions
- Percentage area occupied by transportation infrastructure
- Proportions of city with urban design guidelines
- Proportion of city allowing mixed-use, higher-density development
- Net density
  - Of dwelling units
  - Population
  - Jobs
  - Persons per household or dwelling unit
- Amount of litter on streets
- Miles of traffic-calmed streets
- Number within walking distance of social service agencies
- Percentage voting in elections
- Number of sport facilities
- Number of seats for arts and culture
- Number of historic building listings
- Number of art collections open to public
System Efficiency and Preservation

- Cost for transportation system services
- Total investment in maintenance
- Origin-destination travel times
- Average travel time
- Average speed
- Percentage of projects rated good to excellent
- Volume-to-capacity ratios
- Operating cost per ton-mile
- Customer satisfaction
- Percentage of on-time transit
- Transit services
- Miles between road calls
- Ease/cost of enforcement
- Percentage of VMT on roads with deficient ride quality
- Percentage of roads and bridges below standard condition
- Remaining service life
- Maintenance costs
- Roughness index for pavement
- Service miles between road calls for transit vehicles
- Vehicle age distribution

General Performance Indicators

- Service area population
- Network
  - Length
  - Extent
  - Density
  - Lengths of arterial, expressway, and HOV lanes
  - Parking facilities
  - Rail lengths where applicable
- Percentage of service area population served (within x minutes of service or destination)
- Service area size
- Passenger trips
- Passenger-miles
- Vehicle-miles
- Ton-Miles of freight
- Per capita auto use (car/truck sales)
- Total traffic volumes for road, rail, ship and air
- Total passenger volumes for road, rail, ship and air
- Transit use
- Average home-work trip distance/time taken
- Subsidies to transportation
- Percentage of pavement meeting performance standards
- Revenue miles
- Vehicle-hours
- Revenue hours
- Route miles
- Total operating expenses
- Total maintenance expenses
- Total capital expenses
- Federal contribution
- State contribution
- Total local revenue
- Local contribution
- Directly generated non-fare revenue
- Passenger fare revenue
- Total employees
- Transportation operating employees
- Maintenance employees
- Administrative employees
- Vehicles available for maximum service
- Vehicles operated in maximum service
- Spare ratio
- Parking spaces for employees off the road
- Seat miles during peak and off peak
- Road utilization index (vehicle miles/lane miles)
- Total gallons consumed
- Total energy consumed (kW-h)
  - Vehicle—miles per gallon
  - Vehicle—miles per kW-h
- Quantity of travel
  - Person-miles traveled (AADT*length*vehicle occupancy)
  - Truck-miles traveled (AADT*length*%of trucks)
  - Vehicle-miles traveled (AADT*length)
  - Person trips (total person trips)
- Ridership (total passenger trips)

Transit Availability, Utilization, and Performance
- Vehicle-miles per capita
- Integration of transit with other modes
- Public transportation performance
- Cost of transit relative to cost of gas
- Transit operating ratio (revenue/operating cost)
- Weekday span of service (hours)
- Route miles per square mile of service area
- Vehicle-miles per peak vehicle
- Vehicle-hours per peak vehicle
- Revenue miles per vehicle-mile
- Revenue miles per total vehicles
- Revenue hours per total vehicles
- Revenue hours per employee
- Passenger trips per employee
- Average fare
- Miles between road calls/incidents
- Miles per unit of fuel and power
- Maintenance cost per mile
- Vehicles out of service

Project Progress and Delivery
- % complete versus % scheduled
- % spent versus % budgeted
- DBE (disadvantaged business enterprise) participation – also known as HUB (historically underutilized businesses)
- Major variances and exceptions
- Grant revenue status

Engineering
- Estimated costs
  - Construction
  - Row
  - Utilities
  - Relocations
  - Environmental mitigation
  - Life cycle cost
- Number of design exceptions required
- Exceptions to access management policy
- No. driveways
  - Relocated
  - Closed
  - Combined
  - With newly restricted access (lost)
  - Left turn inbound
  - Left turn outbound
  - Throughs
  - Right turns
- Number of percent of at-grade railroad crossings
- Amount of ROW required
- Number of relocations
- Ease of maintaining traffic
- Ease of maintenance
- Emergency/detour capability
- Adequacy of sight distances
  - Stopping
  - Intersection
  - Decision
Appendix B. Transportation-Related Performance Measures – Context

From Transit-Oriented Development: Developing a Strategy to Measure Success, NCHRP Research Results Digest 294, Alan M. Voorhees Transportation Center, Rutgers University, Transportation Research Board, Washington, DC, February 2005.

This report contains several different types of indicators that might be adapted for use in assessing performance related to walkable urban thoroughfares planned and designed using CSS. Many of these describe context surrounding transportation facilities and projects as well as value capture. Among them are:

Private Investment, Commercial
- New or substantially rehabilitated retail/office space
- Estimated private investment
- Estimated new property taxes generated

Private Investment, Residential
- New or substantially rehabilitated housing units
- Estimated private investment
- Estimated new property taxes generated
- Number of new studios/one bedroom
- Number of new two bedrooms
- Number of new three or more bedrooms
- Number of new units for sale
- Number of new units for rent
- Number of new subsidized units for rent and for sale (with income limits)

Housing
- New or substantially rehabilitated housing units
- Minor housing improvements
- Estimated private investment
- Estimated new property taxes generated
- Estimated increase in property value

Pedestrian
- Length of improved streetscape
- Number of improved intersections/street crossings for pedestrian safety
- Length of façade improvement
- Pedestrian activity counts

Parking
- Number of new spaces for shoppers only
- Number of new spaces for commuters only
- Number of spaces that are shared
- Number of new bicycle racks or lockers provided
Traffic Flow
- Number of new shuttle or jitney services provided to and from the transit station
- Number of traffic control or flow improvements

Land Use
- Amount of brownfield properties remediated under an approved plan
- Number/size of vacant buildings rehabilitated or replaced
- Number/amount of underutilized/vacant lots reclaimed for construction or green/recreation space
- Number of new or improved park areas
- How would you rate your town/neighborhood as a place to live?

Neighborhood Surveys
- Percent who feel the downtown (or transit station area) is more or less attractive now compared to (number) years ago?
- Percent who feel it is more or less pleasant to walk around the downtown (or transit station area) now compared to (number) years ago?
- Percent who feel the downtown (or transit station area) seems more or less safe now compared to (number) years ago?
- Percent who feel that the downtown (or transit station area) offers better or worse shopping now compared to (number) years ago?
- Percent who feel that the downtown (or transit station area) offers more or less restaurant options now compared to (number) years ago?
- Percent who feel that the downtown (or transit station area) offers more or less entertainment options now compared to (number) years ago?

Other
- Net increase in dwelling
- Total construction activity residential construction activity (units or value)
- Affordable housing units created
- Nonresidential construction activity
- Total businesses in transit village town/transit village
- Parking spaces in transit village
- Acres of brownfields reclaimed
- Transit ridership counts
- Pedestrian activity counts
- Public perception survey results
- Public investment
- Number of bicycle racks or
- Lockers provided
- New or substantially rehabilitated retail/office space
- Number of convenience retail establishments (e.g., dry cleaning, video rental)
- Estimated private investment
- Estimated new property taxes generated
• Qualitative rating of streetscape (i.e., pedestrian-built environment orientation/human scale)
• Pedestrian activity counts
• Number of transit boardings
• Population/housing density
• Estimated increase in property value
• Public perception (administered survey)
• Number of bus, ferry, shuttle, or jitney services connecting to transit station
• Number/square feet of mixed-use structures
Appendix C. Transportation-Related Performance Measures – Roadway Design Features


Several performance measures that could be related to CSS and walkable thoroughfares are contained in this report or can be derived from its findings. Among those that might be useful are:

- Number or rate of pedestrian-vehicle collisions
- Average operating speed
- Roadway width
- Moving traffic lanes
- Percent of street with curb parallel or angle parking
- Percent of street mileage with bidirectional sidewalks or pedestrianways
- Percent of walk time consumed by crossing delays
- Percent of walk distance that is in intersection and driveway crossings
- Volumes of traffic turns crossing walking paths
Appendix D. Transportation-Related Performance Measures – Green Streets


The performance measures below were developed for Complete Streets and Green Streets applications. They support five state DOT goals:

1. **Safety**: Provide the safest transportation system in the nation for users and workers.
2. **Mobility**: Maximize transportation system performance and accessibility.
3. **Delivery**: Efficiently deliver quality transportation projects and services.
4. **Stewardship**: Preserve and enhance California’s resources and assets.
5. **Service**: Promote quality service through and excellent workforce.

The performance measures that would be applicable to walkable thoroughfares planned and designed using CSS are:

**Safety**

- Percentage of Californians who feel safe using non-motorized modes on urban arterials.
- Percent of signalized intersections along 2- or 3-lane arterials with marked crosswalks and one or more of the following: countdown signals, leading pedestrian intervals, bulb-outs, or pedestrian refuge islands.
- Percent of unsignalized 4-way (multilane) intersections along urban arterials with marked crosswalks and one or more of the following: HAWK signal*, yield to pedestrian signage, user-activated overhead warning lights.
- Percent of urban arterial intersections with one or more of the following improvements geared toward bicyclists: bike box*, painted bicycle lane through the intersection*, bicycle signal, functioning bicycle loop detectors, bicycle left turn lane.
- Percent of urban arterials on which the 85th percentile driving speed is no greater than 25 mph.

**Mobility**

- On urban arterials, ratio of bidirectional sidewalk mileage to roadway mileage.
- On urban arterials, ratio of bidirectional Class II bicycle facility mileage to roadway mileage.
- On urban arterials, percentage of intersections that are ADA compliant.
- Percentage of urban arterial projects designed as Complete Streets.
- Number of pedestrian trips on urban arterials.
- Number of bicycle trips on urban arterials.

**Stewardship**

- Ratio of pervious to impervious surfaces on Caltrans urban arterials, including medians, buffer strips, and planter holes.
- Percent of urban arterial lane mileage with tree canopy coverage.
• Percent of urban arterial sidewalk mileage in fair or better condition.
• Percent of urban arterial bicycle lane mileage in fair or better condition.

Service
• Number of agency personnel trained in Complete Streets principles.
• Number of agency personnel trained in Green Streets principles.
Appendix E. Transportation-Related Performance Measures – CSS


Potential performance measures associated with CSS benefits from this report were presented in Table 4. Other quantitative measures identified in case studies documented in the report include:

- Measures of stakeholder involvement
- Number of months by project phases and total project duration (months)
- Index of quality of travel – all modes
- Assessment of opinion and satisfaction level
- Extent of modal inclusion
- Modal connectivity (modal volumes)
- Modal crash frequency, severity
- Expanded options for pedestrians, bicyclists
- Consistency with local plans
- Operating speed (actual/expected)
- Number of legal actions against agency
- Percentage of human and environmental impacts of the alternative used for project compared to other alternatives
- Increased or enhanced mitigation beyond mandated Improved environmental ratio/acres
- Meetings attended by stakeholders
- Decreased dollar cost amount for project delivery
- Number and cost of change orders/scope changes
- Benefit/cost
Appendix F. Additional Transportation-Related Performance Measures – CSS and Walkable Thoroughfares

From “Pedestrian Environments: A Systematic Review Process”

- Effective pedestrian throughway width
- Sidewalk grade
- Quality of lighting
- Level of personal security
- Directness of route
- Legibility (and comprehensibility)
- Surface quality

From The 2002 Designing Streets for People Report

- Effectiveness of process management
- Project staff motivation and skill levels
- Degree of coordination
- Agency understanding of street
- Community satisfaction with management of street
- Feeling of safety and well being in street
- Degree of street fulfillment of desired functions
- Contribution of street to area image
- Ability to attract investment
- Street attractive to visit
- Street contributes to sustainability
- Level of maintenance performance
- Effectiveness of stakeholder involvement

From Abu Dhabi Urban Street Design Manual

- Pedestrian
  - Sidewalk crowding (at rail stations or other major destinations)
  - Average crossing delay including average distance to crossing
  - Frequency of protected crossings
  - Percentage active building edge along sidewalk.
  - Percent sidewalk shaded
  - Average block perimeter
- Transit users
  - Intersection delay
  - Corridor travel time as percentage of speed limit.
  - Passenger crowding
  - Reliability
  - Frequency
  - Service hours
  - Cool waiting areas at stops
- **Bicyclists**  
  - Presence of bicycle lane or separate path  
  - Bicycle level of service,  
- **Motor vehicles**  
  - Level of service (segment)  
  - Corridor travel time.  
  - Standard deviation of average speed

From “Street Networks: Traffic Safety, Travel Mode Choice and Emergency Services”
- Connectivity: link-to-node ratio  
- Emergency response time

From *A Primer on Safety Performance Measures for the Transportation Planning Process*
- **Number of Crashes**  
  - Total  
  - Serious injuries  
  - Fatalities  
  - Fatalities involving bicyclists or pedestrians  
  - Pedestrian fatalities  
  - Speeding-related  
  - Fixed object  
  - Ran-off-road  
  - Intersection  
  - Involving distracted drivers  
  - Involving transit vehicles  
- **Number of transit incidents**  
- **Percent of accessible bus stops**

From “Smart Mobility Performance Measures”
- **Multi-modal Level of service**  
  - **Auto**: vehicle delay (Intersections), stops/mile, % speed limit, median, turn lanes  
  - **Transit**: intersection delay, wait time, ride time, loading time, pedestrian level of service  
  - **Pedestrians**: person delay (at intersections), pedestrian density, sidewalks, buffers, street width, traffic level  
  - **Cyclists**: lane width, traffic and truck count and speed, parking, pavement and stops  
- **Congestion**  
  - Severity  
  - Duration  
  - Degree of traffic diversion  
  - Degree of trip suppression  
- **Speed management**  
  - Geometric design speed/target speed  
    - Horizontal curves  
    - Vertical curves
- Speed suitability
- Network optimization
  - Capital cost
  - Operating cost
  - Maintenance cost
  - Opportunity costs
  - Land efficiency costs
  - Environmental impacts
    - Emissions
    - Noise
    - Energy consumption
- Other
  - Accident rates by mode
  - Universal accessibility (ADA)
  - Frequency of bus service within ¼ mile
  - Displaced households
  - Mode shares of travel

From “Measuring Connectivity as Implementation of Sustainable Communities”
- Block length
- Block perimeter length
- Intersection spacing
- Link/node ratio
- Intersection density
- Route directness index
- Walk score

From Context Sensitive Solutions Performance Measures Literature Review
- Number of undeveloped acres converted to another land use
- Number of acres replanted with native species
- Time to complete EIS, EA
- Maintenance expenditures per mile
- New miles of on-street bike lanes
- Quantity of new and upgrades sidewalks and crosswalks
- Miles of multi-use paths
- Increase in transit ridership

From “State DOT Performance Measurement for Highway Design and Construction”
- Percent of engineering work requiring rework
- Percent of preliminary engineering redo
- Ratio of engineering costs to total project costs
- Number/amount of project costs increases during (planning and) design
- Cost per mile for construction cost
- Percent of projects delivered within programmed costs
- Percent of projects delivered within programmed time
From “Street Typologies and Transport Performance Measures in Seattle”

- Average vehicle travel speed
- Standard deviation of travel speed
- Quality of environment
  - Ratio of building height to width building-to-building
  - Percent complete streetwall
  - Percent fenestration of ground floor
  - Average spacing of doorways
  - Average spacing of street trees
  - Average height of street trees
  - Ratio of pedestrians to vehicles

From “Santa Monica Transportation Report Card Guide”

- Corridor person capacity
- Sidewalk completeness
- Bike facility completeness
- Bike parking spaces
- Walk/bike trip mode share
- Public enjoyment (survey)

From Guide to Effective Freeway Performance Measurement: Final Report and Guidebook

- The number, duration, and severity of incidents by location (roadway segment) and type of incident.
- Travel time index.
- Average times for incident duration
- Average times for incident response
- Tow truck response time
- Percent congested traffic
- Percent of day with speeds (in desired range)
- Percent of mileage that is monitored or managed
- Lane closures and durations
  - Incidents
  - Maintenance/construction
  - Lane-miles lost

From Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects

- Development resulting from project
- New businesses resulting from project
- Business upgrades
- Building upgrades
- Increased tax revenues
- Additional employees
- Public improvements
- Change in surface water runoff quality changes to habitats
• Creation of air contamination hot spot
• Change in traffic volumes
• Change in traffic, transit, pedestrian or bicycle access

From *Cost-Effective Performance Measures for Travel Time Delay, Variation and Reliability*
• Individual measures
  o Delay per traveler
  o Travel time
  o Travel time index
  o Buffer index
  o Planning time index
• Area measures
  o Total delay
  o Congested travel
  o Percent of congested travel
  o Congested roadway
  o Accessibility

From *SHRP-C02 Performance Measure Framework for Highway Capacity Decision Making – Web Tool Report* (measures in addition to those listed above)
• Transportation land consumption
• Induced development land consumption
• Consistency of induced land consumption with local plans
• Support by project of (planned) growth centers
• Preserved historical or cultural site or feature
• Preserved community (or neighborhood) cohesion
• Consistency with community interests
• Fair and equitable per environmental justice
• Qualitative cost effectiveness
• Local/regional/state funding partnership
• Private investment

• Maximum block length
• Maximum cul-de-sac length
• Network links ÷ nodes
• Intersections per square mile
• Route directness index (straight line distance ÷ street network distance)

• Street space height-to-width ratio
• Compactness – percent lot coverage
• Percent park space
• Percent green space
• Density
• Setback
• Effective turning radius
• Target speed
• Operating speed
• Pedestrian crossing distance

Suggestions by reviewers of this document:
• Travel time reliability
• Travel speed uniformity
• Perceived safety
• Crosswalk delay
• Longevity – length of time a project exists without requiring changes or additional improvements.
• Project adaptability – ability to accommodate changes in land use types and densities, vehicular and pedestrian traffic conditions, and related environmental conditions after a project is implemented.
• Percent of walkways that are shaded
• Percent active frontage
• Percent of frontage by land use