Developing A Comprehensive Sustainable Transportation Analysis Framework

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ABSTRACT
As climate change has become understood and accepted by state, regional and local governments, there has been a growing impetus to set goals and targets for reduction of greenhouse gas emissions and use of fossil fuels. Tools to prioritize and implement regional and local transportation sector emissions reduction policies have been unavailable to practitioners and policy makers. At the same time, the transportation industry is undergoing a paradigm shift from mobility to access, requiring new ways of defining and evaluating success. Furthermore, transportation agencies are under pressure to deliver projects in a safer, more equitable and cost effective manner. To fill this void, a grass roots group of transportation and sustainability professionals formed to develop a rating system and the planning tools needed to make measurable headway toward improving the performance of transportation in all these areas. Since 2009 the Sustainable Transportation Analysis and Rating System (STARS) has been under development and is being tested on both transportation projects and regional plans. This paper identifies characteristics of STARS that advance the state of the practice while highlighting challenges and gaps. STARS provides a suite of credits incorporating tools and guidance based upon triple bottom line principles. Backcasting is used to establish desired future outcomes, rather than the more traditional forecasting process. STARS uses performance measures to analyze all transport modes and strategies. A pilot project in Santa Cruz County, California is highlighted. Performance monitoring will determine whether the system changes practices and outcomes.

Developing A Comprehensive Sustainable Transportation Analysis Framework

Much has been published about sustainable development and sustainability performance measures as they apply to transportation (*1*,*2*,*3*,*4*,*5*,*6*). Understanding what sustainability means in a general sense and in the realm of transportation has also been researched extensively (*7*,*8*). Additionally, researchers have identified a shift from mobility or automobility to access, which suggests different transportation solutions (*6*,*9*,*10*) Recently work has emerged to develop frameworks for public agencies wishing to incorporate sustainability principles into their activities (1,2). There are four key focus areas or transportation agency functions in which sustainability principles may be applied: planning; programming and project development; construction and maintenance; and system operations (*1*).

The Sustainable Transportation Analysis and Rating System (STARS) is a planning framework and rating system being developed and applied to transportation plans and projects. STARS is being applied to transportation plans and projects in California, Oregon and Washington. The goals of the STARS developers were to meaningfully advance the practice, to provide a framework that is easy to understand, simplify and focus the planning process, be reasonable in cost in application, and impact transportation investments where it matters most.

STARS differs from many transportation rating systems in that it promotes access as well as mobility. It is performance oriented; rather than complying with a list of actions, users must set goals and targets and develop strategies that will meet these targets. STARS is also mode-neutral, allowing comparisons among different strategies in order to determine which strategies achieve the desired outcomes. STARS is built upon triple bottom line principles of sustainability of social benefit (health, safety and vitality), economic prosperity (cost effectiveness) and environmental/ecosystem health. An overarching principle of equity within and between each of these principles is embedded in the framework. STARS is focused on the planning, programming and project development and systems operations phases; the developers of STARS recognized that other rating systems provide complementary standards that address the construction phase of transportation projects. STARS is designed primarily for application in urban and suburban areas.

BACKGROUND

Work on STARS began in 2008 when Portland, Oregon Bureau of Transportation policy staff convened transportation and sustainability professionals to explore developing an outcome-based framework that streamlined and focused economic, environmental and equity analyses for transportation plans and projects. STARS developers recognized that transportation lagged behind the energy and building sectors in adopting economically and environmentally sustainable standards and practices, an observation shared by Samberg et al (*4*).

Furthermore, it appeared that no comprehensive framework existed with which practitioners could assess the sustainability of projects and plans, or determine which performance targets and measures would be most useful in reaching sustainability goals. Bureau staff drew inspiration from Leadership in Energy and Environmental Design (LEED; US Green Building Council) and the Living Building Challenge, a product of the International Living Future Institute (*11*). These organizations have developed planning and design criteria,

certification and rating systems that are currently making significant impacts on life-cycle building performance. Buildings with "net-zero" energy use are now being designed and built (*12*). The Portland group conceived a comprehensive schema to address the lack of adequate planning and analytic tools to integrate sustainability principles and metrics into transportation plans and projects. That system became STARS, the Sustainable Transportation Analysis and Rating System. The STARS framework is documented in three comprehensive manuals: STARS-Plan, STARS-Project, and the STARS Safety, Health and Equity Credits. STARS is being tested on seven public agency applications in the western United States.

OTHER RATING SYSTEMS

Several sustainable transportation rating systems exist; some are state-level systems and others are national in scope. Samberg (*4*) provides an overview of several rating systems, including LEED, Greenroads, GreenLITES, STEED, I-LAST, and STARS. In this paper, Greenroads, GreenLITES, I-LAST, STEED, INVEST, and Envision are reviewed and their key features summarized.

These systems cover similar areas of concern. Habitat protection and enhancement, stormwater management, material use and reuse, context-sensitive design, light pollution, noise abatement, public outreach, land use compatibility, and construction practices are addressed in most of these systems. Regarding traffic operations, many systems reward strategies such as HOV lanes, transit signal priority, bus stop amenities, and coordinated signals. Most systems provide credit for improving bicycle and pedestrian facilities. In general, the systems are weighed more heavily on environmental credits (such as stormwater, habitat, vegetation, material use), although livability also factors in strongly. Less prominent in these systems are credits for addressing equity, economic benefit, and cost effectiveness.

Most of these systems address sustainability on projects, although each places emphasis in different areas. A comprehensive rating system or framework would apply sustainability principles at every phase of a project: planning; programming and project development; construction and maintenance; and operations. As each rating system matures, it is possible that one system with a strong focus on design and construction could be paired up with a complementary rating system focusing on planning, project development, and operations. In its current state STARS addresses these latter focus areas, leaving construction and design to others. The other rating systems focus primarily on the design and construction phase of projects, with the exception of Invest for System Planning and Operations and Maintenance.

Greenroads

Greenroads provides a range of credits applicable primarily at the time of construction or shortly thereafter. Greenroads is designed for use at the project scale. As a result, the framework tends to focus on material and design concerns, with a separate category for pavement. As the name suggests, the system is oriented toward roads and on environmental aspects of projects, although access and equity are addressed. The credits most closely resemble those offered by GreenLITES and I-LAST, although Greenroads includes a life cycle assessment as part of the Materials and Resources category. Absent from the 37 scoring criteria are land use and programmatic (TDM) elements. Greenroads is fully developed as a certification system, with project reviewers independent of the project team. Greenroads is administered by a non-profit foundation and the University of Washington.

GreenLITES

GreenLITES is a New York State Department of Transportation program designed primarily as an internal management program to promote sustainability among its state roadway projects. Samberg observes that many of the goals duplicate the process of the National Environmental Policy Act. GreenLITES shares similar categories as Greenroads and I-LAST. It includes transportation system management and land use categories, but none are provided for programmatic elements such as TDM. GreenLITES is a self-certification program.

GreenLITES for Sustainable Planning is under development. It is a project solicitation tool to evaluate which projects should be included as part of the state's Transportation Improvement Program.

I-LAST

The Illinois Livable and Sustainable Transportation (I-LAST) Rating System and Guide was developed by the Joint Sustainability Group of the Illinois Department of Transportation, the American Council of Engineering Companies–Illinois, and the Illinois Road and Transportation Builders Association. I-LAST is a system for Illinois agencies to use voluntarily, and was designed to provide a comprehensive list of sustainable practices to project managers, a simple method to evaluate projects, and recognize the existing use of sustainable practices in the industry. As a point-based system, projects can be simply evaluated, although developers caution not to use absolute scores to judge the merit of projects.

Envision

Envision™ is the product of a joint collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure. The Institute for Sustainable Infrastructure is a not-for-profit association of the American Society of Civil Engineers, the American Council of Engineering Companies and the American Public Works Association. Envision is an infrastructure rating and recognition system not only for transportation projects, but many kinds of infrastructure development. It has a unique category of Climate and Risk that accounts for natural hazards, and climate change mitigation and adaptation. Furthermore, it is unique in its degree of reflection, asking not only "Are we doing the project right?" but also "Are we doing the right project?" (*13*). Because Envision is intended to address all kinds of infrastructure projects, it is, by design, limited in how comprehensively it addresses transportation projects. The developers of Envision anticipate that other sector-specific rating systems would complement Envision by offering additional detail (*14*).

INVEST

INVEST (Infrastructure Voluntary Evaluation Sustainability Tool) was developed by the FHWA to address sustainability throughout the life cycle of transportation investments; specifically, highways. It contains three modules: INVEST for Systems Planning, INVEST for Project Development, and INVEST for Operations and Maintenance. The developers of INVEST acknowledge that it is difficult to make highways fully sustainable, but it is possible to make them more sustainable than they are today. They also acknowledge that the purpose of transportation is not just to provide mobility, but also to provide access. INVEST provides a list of best practices, called criteria, that may be incorporated into projects. Criteria are less specific than those suggested by other systems; users are not directed toward specific actions, but rather

are often asked to set goals. Additional points are rewarded for monitoring performance over time. Developers note that points are not rewarded for more sustainable practices that are already required, such as complying with the NEPA process. INVEST for System Planning includes criteria for financial sustainability, travel demand management, and infrastructure resiliency, which are not featured in most other systems. INVEST is designed as a self-evaluation tool (*15*).

STEED

Lochner's Sustainable Transportation Engineering and Environmental Design (STEED) program provides users with a checklist of things to consider when developing transportation projects. In earlier versions, STEED was organized as a rating system, but is currently used as an evaluation framework focused on continual improvement rather than award levels. As Samberg observes, one of the key features of STEED is that projects are evaluated at multiple stages of the process: Planning, Environmental, Design, and As-Built. STEED also is outcomes-oriented, which differentiates STEED from many transportation rating systems. STEED includes a lifecycle analysis in its framework. Equity and economic impacts are more comprehensively addressed in STEED than in some of the other systems.

The developers of STARS chose to focus on transportation planning and operations because decisions made in these stages determine what will ultimately be constructed and have the greatest impact on the economy, energy consumption, greenhouse gas emissions and safety (*16,17,18*). STARS is also performance-oriented and mode neutral, not only allowing agencies flexibility in how they reach desired outcomes but also ensuring that outcomes are realized (rather than adding strategies that may not translate to real results). STARS is intended to be used as a planning framework as well as a rating and certification system. That is, STARS can be used to help agencies simplify the process and improve the performance of plans and projects without pursuing a rating or certification. However, STARS will include a third-party rating and certification, which is under development.

UNDERSTANDING SUSTAINABILITY

One of the initial tasks for the STARS group, in addition to determining the goals of the system, was to agree on a definition of sustainable transportation. As Samberg et al, Litman and Burwell (*8*) observe, the greatest challenge is in defining sustainable transportation. It is the experience of STARS developers that an inadequate definition of sustainability often creates lack of specificity, too narrow of scope for exploring solutions, and trade-offs among the dimensions of sustainability. For these reasons, STARS developers require a sustainability workshop at the outset of a plan or project (see below). It was agreed to use the following definition from the Centre for Sustainable Transportation (*19*) to guide and measure STARS' effectiveness as it is developed and applied.

"Sustainable transportation:

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the

sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise."

The STARS developers also adopted the principles of The Natural Step (*20*) to assess the performance of STARS over time. The Natural Step identifies three basic conditions that must be met to maintain the essential natural resources, structures and functions that sustain the ecosphere, and a fourth condition that recognizes the ability of human beings to meet their basic needs. Together these are known as the Four System Conditions. The Conditions state that in a sustainable society, nature is not subject to systematically increasing:

1) concentrations of substances extracted from the earth's crust;
2) concentrations of substances produced by society;
3) degradation by physical means; and
4) people are not subject to conditions that systemically undermine their capacity to meet their needs (*20*).

These concepts are embedded in the definition of sustainability described above.

The STARS developers needed an easily understood organizational framework for explaining sustainable transportation principles and analyzing the multiple benefits and costs of alternative actions. The team decided to use the triple bottom line framework (*21,22*) to organize benefits and impacts of decisions based upon three dimensions of sustainability: social equity, environmental quality and economic prosperity. These dimensions, also known as pillars of sustainability, are sometimes identified as the three P's – people, planet and prosperity. The STARS framework uses the triple bottom line to identify goals, targets, policies, performance measures and strategies that will best achieve multiple positive outcomes.

Emphasis on optimizing all three dimensions recognizes the interrelation of people, planet and prosperity. Balancing often results in trade-offs between the three dimensions and results in what is termed a weak approach to sustainability. In a weak approach, the trade-off of human-created and natural capital is acceptable. In a strong approach, natural resources are recognized as limited and given equal or greater consideration (*1,23*). In this sense, the STARS approach to the triple bottom line can be described as a strong approach to sustainability, in that it focuses on optimizing for the three variables so that trade-offs are minimized and natural capital is not compromised. The STARS approach is to encourage three-dimensional thinking: incorporation of those measures and strategies that will maximize net benefit to all three dimensions of the triple bottom line simultaneously.

FEATURES

The STARS application manuals share five key characteristics. First, they are performance based. This is a critical aspect allowing STARS to be a comprehensive framework, and essential for the rating system to maintain consistency with the adopted definition of sustainability and foundation principles. Instead of complying with a prescribed list of actions, STARS requires users to evaluate which strategies are likely to achieve the desired outcomes, and then to select appropriate performance indicators. As Bossel observes, defining an appropriate set of indicators for sustainable development is a difficult task, which can be accomplished by a system-based approach *(5).* STARS developers save the user the time and effort of identifying such indicators and suggest a limited set of indicators that will accomplish sustainable goals. Selection of appropriate indicators is an important step in the process (*3,6).* This performance-orientation is also consistent with the description of a sustainability framework suggested by Ramani et al (*1*).

Second, STARS is mode-neutral. This approach allows for ease of comparison across different means to achieve the targets and outcomes the agency has selected. It also recognizes that each community is different, and that there is no "one-size-fits-all" solution to its transportation goals. Practitioners are increasingly looking for policy, planning and design tools that do more than replicate the past into the future. Studies such as Moving Cooler (*24*) have shown that no single strategy can achieve the outcomes needed to reverse the growing accumulation of greenhouse gases in the atmosphere.

Third, the focus is on improving access to key destinations, goods and services. This shift in focus from mobility to access is a trend documented by Zietsman (*6*) and is gaining acceptance in planning practice. Emphasis on access allows for a broad and comprehensive suite of solutions to address the transportation needs of a community. For example, in the STARS Access and Mobility credit, users are asked to increase the proportion of the population within a 30 minute walk, bike, or transit trip to key destinations such as school, work and healthy food sources. This improvement could be made by closing gaps in the pedestrian and bicycle network, supporting mixed-use development, or improving signal timing for transit. Since STARS is performance-based and mode neutral, it is up to the user to determine which of these strategies would best improve access to key destinations.

A fourth feature in STARS is backcasting. Backcasting, unlike forecasting, starts by asking what future outcomes a community wants to achieve, then analyzes potential actions to determine which are most likely over time to achieve the desired outcomes. Backcasting is recommended by The Natural Step *(20).* Barrella and Amekudzi identify backcasting as "a better option than forecasting for analyzing transportation sustainability problems" and go on to say that, "In light of the major challenges facing the transportation industry – like climate change and financial crisis – planning activities should focus on shaping the future, not predicting it."(*25*) Forecasting extrapolates past trends into the future, following a linear path to one deterministic outcome, whereas backcasting supports a creative process encouraging discovery of multiple options (*25*,*26*). Backcasting, when used with forecasting, can provide a powerful tool to shift the focus from symptoms, such as "congestion," to outcomes, such as improving travel time reliability, reducing greenhouse gas emissions and producing the greatest societal benefits for the least public, private and social costs.

Fifth, STARS examines public, private, and social costs and benefits over the short, medium, and long-term. Typically, cost benefit analyses of plans and projects only account for the public cost of investment. However, in STARS, the costs incurred by private actors are factored into the analysis. Additionally, the societal cost of greenhouse gas (GHG) emissions is included. Incorporating a longer timeframe, to the year 2050, is critical to a more comprehensive understanding of the benefits and costs of a project or plan, since typically most of the GHG emissions are generated through operation of vehicles on the facility after it is built. The traditional twenty-year planning horizon focusing only on public agency costs provides partial and incomplete information. A fuller analysis begins to address GHG emissions as being cumulative and planetary in nature. The longevity of CO_2 in the atmosphere is probably the least well understood part of the global warming issue, but there is general agreement that the impacts of burning fossil fuels upon climate run into the hundreds of years. The longer time frame is also based on the fact that many state and local governments have developed goals and policies for GHG emission reductions out to 2050.

STARS APPLICATIONS

STARS-Plan, STARS-Project and the STARS Safety, Health, and Equity Credit Tool comprise the suite of STARS applications. Version 1.1 of STARS for Transportation Projects (STARS-Project) was published in February 2011, version 1.0 of STARS for Transportation Plans (STARS-Plan) was published in January 2012 and the STARS Safety, Health and Equity Credit Tool was published in March 2012. An overview of the three applications is presented below.

STARS-Project

STARS-Project, the first of the STARS applications to be created, was developed in 2010 through a partnership between the North American Sustainable Transportation Council (STC) and the Santa Cruz County Regional Transportation Commission (SCCRTC). This work included developing the first twelve STARS-Project "core credits" of a total of twenty-nine originally envisioned. The STC contracted with five private sector firms to develop these core credits. The credits were refined through an iterative process involving several expert technical advisors and a twenty member volunteer technical advisory team under the guidance of the SCCRTC. STARS-Project can be used for road, transit, bicycle, pedestrian and multimodal corridor analyses (*27*).

STARS-Plan

STARS Plan builds upon the core credits developed in STARS-Project and is tailored for integrating sustainability into local Transportation System Plans (TSPs), Regional Transportation Plans (RTPs) and modal plans (e.g., a bicycle master plan). The first phase of STARS-Plan is the framework for establishing triple bottom line goals, targets and policies, published January 2012 as the *STARS Pilot Plan Application Manual, version 1.1* (*28*).

STARS Safety, Health, and Equity Credits

In the public health sector, there has been growing interest in addressing the increased occurrence of obesity and related health conditions, and the associated decrease in non-motorized travel. In 2011-2012 a set of credits for Safety, Health and Equity was developed through a partnership of the STC; Upstream Public Health, a Portland, Oregon nonprofit organization; and the City of Portland Bureau of Transportation. The credits ask applicants to analyze and select project alternatives that promote equitable outcomes, leading to "the lack of differences in travel-related population-based outcomes that are avoidable, unfair, and based on social attributes of age, race, ethnicity, class, income, disability, gender, or other distinguishing aspects of social position." (*29*) The Safety, Health and Equity credits can be used as a stand-alone evaluation tool or integrated as part of a STARS-Plan or STARS-Project application (*30).*

PROCESS AND STRUCTURE

The process and structure of STARS is consistent with the sustainability framework proposed by Ramani et al. Their first step is understanding sustainability, which they recommend defining as a set of principles, and then following with a framework that includes goals, objectives, and performance measures. Performance measures should be sustainable, versus conventional, although they note that no one performance measure represents sustainability in isolation. *(1)*

Specifically, the procedural aspect of STARS is covered under its Integrated Process credit. The Integrated Process establishes a foundation upon which the credits are developed. All STARS users are required to complete this primary step. It is procedural in nature and does not

have a set of goals, objectives and measures associated with it. It involves developing a common understanding of sustainability, a step that is frequently recognized as essential to any process of evaluating sustainability in the transportation sector.

The five steps of Integrated Process are summarized below:

1. Develop an interdisciplinary project team. STARS places a strong emphasis on assembling a cross-disciplinary team early in the planning process before key decisions are made. A broad array of expertise is recommended to include ecology, public health, landscape architecture, bicycle and pedestrian safety, and representatives of transportation-disadvantaged populations.
2. Sustainability education. Ensure that both the project team and a diverse group of stakeholders learn about sustainability benefits and have common knowledge of the STARS definitions and principles.
3. Acquire baseline data related to goals, objectives and measures.
4. Engage with the community through committees, surveys, and other outreach efforts. Flexibility is allowed in tailoring a particular outreach strategy to the needs of the community.
5. Backcasting. Engage in a backcasting process to establish targets for objectives. Work begins on completing credits after a STARS user has fulfilled the Integrated Process requirements.

STARS-Plan, STARS-Project, and the STARS Safety, Health, and Equity Credits are built upon the same foundational principles and processes. The intention is that performance measures used at the plan level can also be applied at the project level. Differences in the applications involve the number and complexity of credits. The requirements and relationships between many of the credits indicate a high level of integration. This discussion will focus on STARS-Plan as an illustration of the organizational structure and key characteristics of the STARS approach, as it is now being applied in three pilot plans.

In general, STARS is organized according to credit categories. This is defined as "transportation sustainability goal development" within the proposed framework *(28)*. Within each category, a set of goals, objectives, and performance measures are tiered. The credit categories in STARS-Plan illustrate the variety of subject areas addressed:

1) Access and Mobility
2) Safety and Health
3) Equity
4) Economic Benefit
5) Cost Effectiveness
6) Climate and Energy
7) Ecological Function
8) Community Context

Each credit category has associated goals, each goal has one or more associated objectives and for each objective one or more performance measures are recommended. Surrogate measures are suggested in cases where specific data is not available. The Community Context Credit is optional, and to be defined by users. The complete framework of STARS-Plan version 1.0 is summarized in Table 1.

TABLE 1 STARS-Plan Framework (Credits, Goals, Objectives, and Measures)

Credit Category	Goal	Objectives	Measures
Access & Mobility	Improve people's ability to meet most of their daily needs without having to drive	To improve safe, attractive, and affordable access to work, school, goods, and other key destinations by walking, bicycling, and transit	% of population within a 30-minute walk, bike, or transit trip of key destinations **VMT**
	Improve the convenience and quality of trips, especially for walk, bike, transit, car/vanpool, and freight	To improve travel time and/or travel time reliability for pedestrian and bicycle trips between key origins and destinations To improve travel time reliability and speed consistency for transit, car/vanpool, and freight trips between key origins and destinations To improve the quality of walk, bicycle, car/vanpool, and transit trips	**Travel time reliability** **Speed consistency** Travel time MMLOS grade Address user survey
Safety & Health	Improve multimodal safety, especially for the most vulnerable users	To decrease fatalities and injuries for all travel modes Pedestrian and bicyclist fatalities and injuries will not be higher than their proportion of total trips	**Improvements to areas that have reported fatalities and injuries**
	Improve health by increasing physical activity by people using the transportation system	To increase the percentage of walk, bicycle, and transit trips	Mode share
	Improve air quality	To decrease the quantities of harmful airborne pollutants	Criteria pollutants
Equity	Reduce disparities in healthy, safe access to key destinations for transportation-disadvantaged populations	To demonstrate that planned investments reduce or eliminate disparities in Access & Mobility, Economic Benefit, Safety & Health between transportation-disadvantaged and non transportation-disadvantaged populations	Percentage of plan spending on projects and programs in areas of key origins and destinations for transportation-disadvantaged populations
	Demonstrate that planned investments do not disproportionately impact transportation-disadvantaged populations	To demonstrate that transportation-disadvantaged communities do not experience disproportionate impacts from transportation construction or operations	Transportation-related criteria pollutants **Travel time reliability** Traffic noise exposure

Note: **Bold** measures are primary measures.

Credit Category	Goal	Objectives	Measures
Economic Benefit	Re-invest in the local economy	To re-invest in the local economy through reducing expenditures on fuel and related vehicle use	**VMT** / dollars **Speed consistency**
	Improve economic access	To increase practical and convenient access to employment centers by multiple modes	% of population within a 30-minute trip by mode
	Improve travel time reliability and speed consistency for high-value trips	To improve travel time reliability and speed consistency for freight between representative origins and destinations	**Travel time reliability** **Speed consistency**
Cost Effectiveness	Optimize benefits over the life-cycle of the project	To optimize benefits relative to public, private and social costs over the plan's time horizon	Compare benefits (e.g. reduced VMT, improved travel time reliability) to costs
	To prioritize the enhancement and maintenance of the existing system over system expansion	To maintain pavement condition on roadways to 75% and demonstrate the cost of routine maintenance vs. deferred maintenance (street network) To maintain average asset age no more than 50% of the useful life and to maintain service calls to an average of 8,000 miles (transit)	Pavement condition Routine maintenance costs Deferred maintenance costs Average asset age Service calls
Climate and Energy	Reduce greenhouse gas emissions and fossil fuel consumption	To reduce fuel consumption To improve speed consistency between origins and destinations, by multiple modes To reduce fossil fuel use for operations	**VMT** **Speed consistency** Fuel consumption
Ecological Function	Avoid or improve habitat	To avoid or minimize impacts to local, state, and federally defined sensitive areas To improve habitat in or adjacent to the right-of-way To increase the percentage of tree canopy in rights-of-way	Amount and quality of area Amount and quality of habitat Tree canopy
	Improve water quality and stream flows	To manage and treat stormwater volumes and flow on-site through LID practices	Post-development conditions relative to pre-development conditions
Community Context	TBD by local agency and community		

Note: **Bold** measures are primary measures.

Goals, Objectives, Performance Measures, and Targets

STARS goals are aspirational statements. Objectives provide the means to achieving goals. Objectives are quantified through performance measures and have a targeted level of improvement within a specified time frame. Performance measures evaluate how well an objective has been met. The criteria used for selecting performance measures are below:

- **Comprehensibility** – Are the performance measures sufficiently well defined so that they are clearly understandable to decision makers and managers?
- **Feasible** – Can the data needed to assess the measure be collected and analyzed cost effectively?
- **Data** – Is sufficient data available to determine the performance measures now and to forecast them in the future?
- **Leading** – Can the measure be used for predicting future conditions (modeled) or can it be calculated using GIS?
- **Relevance** – Do the performance measures reflect the outcomes of the alternatives? Do the performance measures provide information on how to rank different alternatives? Are the performance measures directly related to the goals and objectives?
- **Multi-modal** – Does the measure address multiple modes, whenever appropriate and able?
- **Scalable** – Does the measure work at multiple scales, such as a corridor and plan level?
- **Triple Bottom Line** – Does the measure reflect outputs that affect more than one dimension of the triple bottom line?

Performance measures are identified as Primary Measures when they achieve many objectives. These measures are considered the "heavy lifters" in that they represent the primary outcomes desired. The Primary Measures are:

- Reduce Vehicle Miles Traveled (VMT)
- Improvements to areas that have reported fatalities and injuries
- Improve travel time reliability
- Improve speed consistency

Many Secondary Measures are recommended, including: mode share; criteria pollutants; travel time; multi-modal level of service grade; percent of population within a 30-minute walk, bicycle or transit trip of key destinations; percentage of plan spending on projects and programs in areas of key origins and destinations for transportation-disadvantaged populations; traffic noise exposure; comparison of benefits (e.g., reduced VMT) to costs; pavement condition; fuel consumption; amount and quality of habitat; tree canopy; and others.

STARS recommends avoiding use of some traditional evaluation measures which focus primarily on a single mode and do not include cross-dimensional impacts. In contrast, Primary Measures are multi-modal and strive to maximize benefits to the triple bottom line. The indicators recommended in the STARS manuals are consistent with principles recognized as best practices in the literature (*3*).

STARS uses backcasting as a way to set targets. Using the performance measures to identify the outcomes desired, STARS users set a target for a specific timeframe. Targets may be based in part on a policy context, such as state mandates for greenhouse gas emissions reductions, or based on "stretch" targets (e.g. doubling mode share).

IMPLEMENTATION/ CASE STUDY

SCCRTC Regional Transportation Plan

A partnership between the Santa Cruz County Regional Transportation Commission (SCCRTC) and the STC was formed in 2010 to apply sustainability principles to a nine-mile corridor on California State Highway 1. The SCCRTC board and the public found the STARS framework helpful in identifying how the triple bottom line framework could address multiple community values and inform decision-making. Most importantly, the STARS conversation built trust with the public and improved the transparency of the planning process. While the specific project that prompted the development of STARS, the Highway 1 Corridor, was scaled back due to lack of funding, the value of STARS had already been demonstrated to SCCRTC. Thus, it seemed natural to turn to STARS as a potential framework for updating their Regional Transportation Plan, starting in early 2011. The update of the RTP was needed to meet new state mandates that require regions to set GHG reduction targets and to delineate how those targets will be met. New planning guidelines require that Metropolitan Planning Organizations (MPOs) develop a Sustainable Communities Strategy (SCS) in their Metropolitan Transportation Plans. The SCS must show how changes in land use and future transportation policies, goals and strategies will work together in meeting future emission reduction targets. The SCCRTC is working with the region's MPO, the Association of Monterey Bay Area Governments (AMBAG), to coordinate its sustainability work to ensure that targets are met. The previous RTP updates had resulted in a laundry list of goals, policies, and projects, a common practice in transportation planning. The long lists ensured everyone found something to like, but failed to prioritize the most valuable actions and investments.

The STC and SCCRTC created an Expert Advisory Panel of transportation and sustainability professionals located primarily on the West Coast, working in the private sector and public sector among local, state, and federal governments. The feedback from the Panel formed the basis for the STARS framework applicable to transportation plans. This collaboration resulted in the publication of a guideline document, the *STARS Pilot Plan Application Manual*, which can be used by any agency or consulting firm interested in using a triple bottom line framework to streamline and improve outcomes from a local or regional transportation plan process (*22*).

The STC and SCCRTC staff then applied the STARS framework to the RTP. The STC and SCCRTC staff collaborated to identify just three top goals and ten top "targets" most likely to provide the greatest triple bottom line benefits to Santa Cruz County residents and businesses. By focusing on crosscutting targets and policies – those that achieve "double win" or "triple win" outcomes – the team was able to reduce the number of RTP goals, targets, policies and strategies. This will allow for a more streamlined and focused alternatives analysis and an RTP that is much more accessible to decision makers and the community. After a public workshop and over 600 survey respondents, the SCCRTC Board unanimously adopted the "Draft Transportation Plan Goals, Targets and Policies" on May 17, 2012. At just three pages, the document provides an explicit triple bottom line framework for developing and evaluating projects and programs *(31).*

In addition to the work with SCCRTC, the Sustainable Transportation Council is applying STARS to several other plans and projects:

1. City of Eugene Transportation System Plan update. Eugene is using STARS to inform Transportation System Plan goals, objectives, and performance measures for project prioritization.
2. Tacoma Avenue Station Area Plan for the Portland Milwaukie Light Rail line. STARS is being used to identify key performance measures for several zoning, parking and transportation improvement alternatives around a planned light rail station.
3. Clark County, Washington, C-TRAN 4th Plain Transit Improvement Project. C-TRAN is using STARS to identify the economic and environmental benefits and costs of Bus Rapid Transit (BRT) alternatives along a major corridor. The cost effectiveness analysis includes public, private and social costs, providing decision-makers a more complete and accurate picture.
4. City of Gresham MAX Path. STARS is being used to establish triple bottom line goals, objectives and performance measures for a two-mile bicycle/pedestrian trail adjacent to the MAX light rail line.

CHALLENGES AND LESSONS

The Sustainable Transportation Council has found that early education about sustainability, sustainable transportation, and understanding the STARS framework has been critical to the success of the pilot plan or project. In instances where comprehensive education about the triple bottom line, optimizing and outcome-based decision-making was not provided at the outset, the tendency was to proceed "business-as-usual," focusing on the construction phase and making trade-offs between suboptimal alternatives. The STC has found that well designed and interactive workshops initiated early in the planning process build the trust and understanding of stakeholders needed to apply new principles and practices through completion of a project or plan. Many stakeholders arrive at a workshop or meeting without a clear understanding of what sustainability means when applied to transportation. Others arrive with a very narrow definition in mind. A common approach is to focus on a single mode as the solution to all transport challenges. Providing a framework with a focus on multiple outcomes helps open the discussion to consider many strategies.

Because STARS is mode-neutral, users will consider more strategies than they might otherwise. In particular, the framework rewards analysis of Transportation Demand Management (TDM) and Transportation System Management (TSM) strategies. In STARS-Project, analysis of TDM and TSM strategies are each assigned a credit under the Access category. TDM has been gaining recognition internationally as an important set of strategies to improve safe and effective use of infrastructure (*32*). Encouraging users to consider multiple strategies supports a collaborative and exploratory approach, qualities that can help advance awareness that sustainability in transportation requires multiple strategies, as was demonstrated in the 2009 report *Moving Cooler*.

In nearly every jurisdiction where STARS has been applied, the greatest focus of conversation has been about data availability and selection of performance measures. This proved to be true in the Santa Cruz application. The regional travel demand model was being updated at the same time the SCCRTC decided to apply STARS to the RTP update. The importance of having a current model and data was clear, yet time and resource constraints did not allow the project sponsor to wait. Because STARS focuses on outcomes rather than methodologies, the project team was able to develop a post-processing methodology to analyze the effectiveness of transit, bicycle, pedestrian, TDM and TSM projects toward achieving the adopted targets. This allowed the STARS RTP work to stay on schedule.

STARS has proven to be a flexible framework. In situations where sustainability is demanded by the public, the STC is perceived as an objective third party to help improve sustainable performance of transportation plans and projects. In other contexts, where sustainability is not a high priority for the community, STARS can be used to inform a planning framework but is not necessary to be highlighted or discussed. The word "sustainability" can be dropped and conversation can focus on the outcomes desired, which most members of the community can support.

In use, the framework provides options to the user. Some steps are mandatory, and others may be selected according to the nature of the plan or project, the goals of the user, and/or resources available. Two goals of the developers - that STARS be easily understood and that it would incur a reasonable cost in application - will continue to be tested as STARS matures and has been applied in practice under variable conditions.

Because STARS is performance-oriented, evaluation is more time-intensive than complying with a list of standards. Some of the performance measures STARS uses are not conventional; not only does this require more effort to obtain data, as mentioned earlier, but new methods of evaluation are required. As such, STARS developers have found it necessary to develop ways to evaluate measures such as access to key destinations, travel time reliability, and cost effectiveness.

NEXT STEPS

STARS developers have received enough feedback about the process and framework from its pilot plans and projects to begin revisions for STARS 2.0. Developers will revise the three manuals to more fully develop and improve the framework, as well as design them to be more consistent with each other, both in content and format. At the same time, STARS developers will detail the rating and certification process; its completion is expected by late 2013. Training on the use of STARS will be available with the completion of the certification system.

CONCLUDING REMARKS

The status of achieving STARS certification will raise the profile of plans and projects, yet the process of achieving that recognition is where the important changes will take place. As the SCCRTC has taken the development of its Regional Transportation Plan through the STARS process, stakeholders and staff have gained deeper understanding of what sustainability means, why it is important in planning a better transportation system, what the essential steps are to attaining that system and, most importantly, to take ownership of eventual implementation. The cross-disciplinary approach embodied in the Integrated Process provides ample opportunity to address issues traditionally considered to be outside transportation by encouraging participation from other sectors. An open collaborative team structure coupled with a more holistic perspective increases the likelihood that plans or projects will score high as "sustainable." Use of the backcasting approach encourages the kind of creativity and iterative learning needed to incorporate sustainable performance into our transportation networks.

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