AT THE CROSSROADS OF ECOLOGY, ECONOMICS, AND SOCIETY: MEASURING SUSTAINABILITY IN TRANSPORTATION

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ABSTRACT

INVEST is a tool developed by the Federal Highway Administration to help transportation agencies learn about, implement, and evaluate best practices in highway sustainability. In the autumn of 2012, FHWA launched Version 1.0 of INVEST after a significant pilot testing process. This paper highlights the outcomes of the pilot test and describes some of the features – many of which were developed as a direct result of pilot test feedback – that have been incorporated into INVEST 1.0.

INTRODUCTION

In October 2012, the Federal Highway Administration (FHWA) launched INVEST 1.0, a voluntary web-based tool (www.sustainablehighways.org) that helps state and local agencies identify opportunities for incorporating sustainability into their transportation projects and programs. INVEST is based upon a collection of sustainability best practices called criteria and includes three broad modules – System Planning (SP), Project Development (PD), and Operations and Maintenance (OM) – that address the full lifecycle of a highway. With INVEST, an agency is able to evaluate each module independently and receive a score based on the number of points achieved for each criterion. More important than the score, however, is the fact that INVEST helps agencies identify and implement additional sustainability practices to improve the economic, social, and environmental outcomes that matter to their stakeholders. INVEST also meets an identified need for a collaborative virtual workspace that promotes communication and encourages participation by a wide range of practitioners, including transportation planners, engineers, construction specialists, asset managers, ecologists, economists, maintenance technicians, and executive leaders.

INVEST was developed over a period of several years and included Beta Test and Pilot Test versions. Before releasing Version 1.0, FHWA used these test versions to ensure that INVEST met the needs of its users, successfully promoted new ways of thinking about transportation sustainability, and remained flexible enough to be useful to different types of transportation agencies in a wide range of geographic locations.

In 2011, FHWA presented a paper on INVEST at the International Conference on Ecology and Transportation (ICOET), shortly after the Pilot Test version of the tool was released. This paper serves as a follow-up report, focusing on the pilot test process, its outcomes, and the changes that were imparted on the tool between the Pilot Test version and Version 1.0. It also provides highlights from a subset of INVEST criteria that may be of particular interest to the ICOET community, including examples of how transportation agencies have used these criteria to improve sustainability.

INVEST BACKGROUND AND PURPOSE

A balanced approach to sustainability relies on the consideration of social concerns, environmental concerns, and economic concerns. Often called the “triple bottom line”, the goal of sustainability is the satisfaction of basic social and economic needs, both present and future, and the responsible use of natural resources, all while maintaining or improving the well-being of the environment on which life depends.

In 2008, FHWA began developing INVEST in an effort to bridge the gap between sustainability concepts and sustainability in action as it applies to transportation and highways. FHWA observed a need for a unifying body of information that provided a way for transportation agencies to learn about sustainability best practices while tracking sustainability accomplishments on the ground. In particular, FHWA wanted

to recognize sustainability efforts in the transportation arena that go above and beyond what is already required by state or Federal regulations.

Several prominent transportation sustainability tools were developed before INVEST, including GreenRoads (developed by the University of Washington), GreenLITES (developed by the New York State Department of Transportation), and iLast (developed by the Illinois Department of Transportation). These tools compiled a wealth of information for practitioners but, at the time, focused primarily on highway design and construction. Thus, FHWA was inspired to create a tool that addresses sustainability for the full lifecycle of a highway, including system-level planning and programming, project development (project-specific planning, design, and construction), and operations and maintenance activities (Figure 1). Also important is the voluntary nature of INVEST, which was designed so that a full self-evaluation could be performed by a state or local agency without Federal oversight or the need for third-party certification of results.

Figure 1: Project Lifecycle
Source: http://www.sustainablehighways.org

BETA TEST

INVEST was first released as a Beta Test version in 2010. While the tool was always available to the general public, FHWA actively sought feedback on this version from state and regional transportation agencies and stakeholder organizations. Major feedback providers included the American Association of State Highway Transportation Officials (AASHTO), the Association of Metropolitan Planning Organizations (AMPO), Federal partners including the Federal Transit Administration (FTA) and the Environmental Protection Agency (EPA), and several state departments of transportation.

More than 1,200 unique comments were fielded and addressed. Many comments focused on the content of individual criteria, while others addressed the overall intent, design, and functionality of the tool. Overall, it was clear that transportation agencies had a keen interest in the tool and the information it provided, but several testers felt that the large amount of technical information in the tool made it less accessible for practitioners new to the field of sustainability. Based on the feedback, INVEST was streamlined significantly. FHWA released a new version, called the Pilot Test version, in April 2011.

PILOT TEST

The purpose of the Pilot Test version of INVEST was to provide a prototype that could be used by agencies who agreed to be closely monitored throughout the pilot testing process. In order to support the pilot test process, FHWA agreed to provide funding support (with a 100% match) to all agencies agreeing to participate. Nineteen transportation agencies around the country participated in the pilot test (Figure 2), and 2,000 additional comments were received throughout the process.

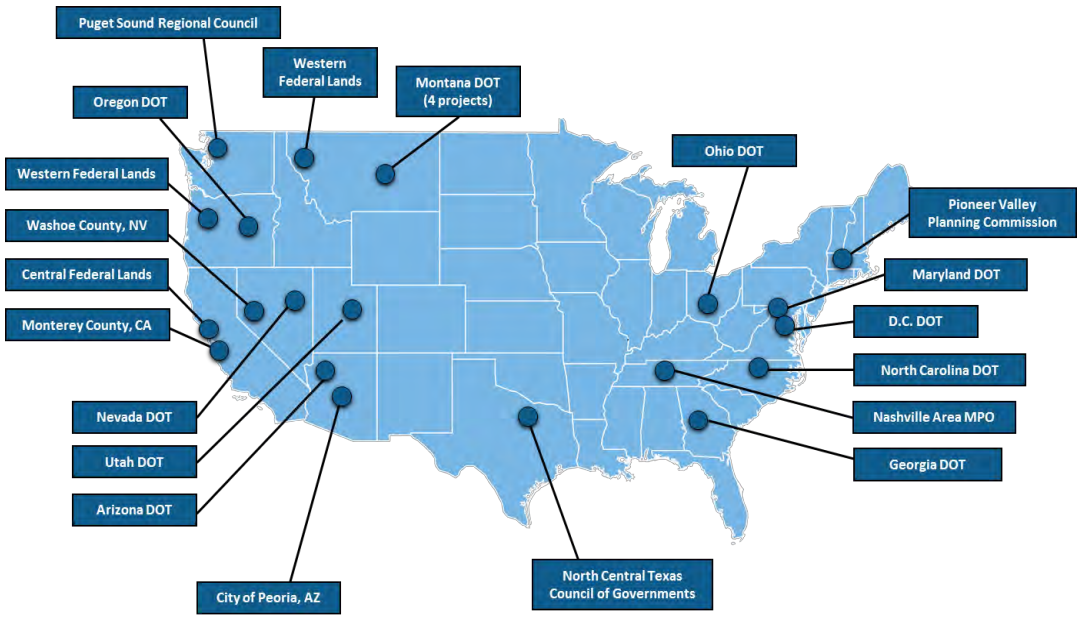

Figure 2: Pilot Test Locations
Source: FHWA

Pilot Test Methodology

The INVEST pilot tests occurred in three phases. The first phase tested the PD module of INVEST; the second phase tested the SP module; and the third phase tested the OM module. Once agencies for each phase were identified, a Project Manager was named as the key point of contact for FHWA and the primary organizer of the agency team that would participate in the testing process. Most agencies completed their pilot tests relying solely on in-agency resources, while a few agencies worked with outside contractors to conduct the effort. Pilot test agencies were given approximately two months to familiarize themselves with the tool, assemble a team of appropriate personnel, and gather all available data necessary to work through the module being tested.

An important goal for FHWA was to emphasize the value of the pilot testing *process* instead of focusing on the final score that an agency received. To support this principle, the testing agencies were asked to organize a full-day scoring workshop, for which a FHWA representative would attend and observe the proceedings. Although the FHWA representative was available to answer questions and provide support during the workshop, the hope was to minimally impact the proceedings so that a true understanding of the tool's usability was attained. In particular, the INVEST development team wanted to see how

different subject matter experts within an agency (a bridge specialist and an ecologist, for example) might work through a particular criterion that related to their respective fields.

Pilot Test Results: Collaboration

The Pilot Tests generated feedback from test agencies that resulted in significant changes to INVEST that would ultimately be reflected in Version 1.0 of the tool. Similar to feedback from the Beta Test Version, some comments focused on the overall functionality of the tool, while others addressed the content and scoring requirements within each of the criteria.

Throughout the Pilot Test process, FHWA emphasized the importance of collaboration when using INVEST to evaluate sustainability. The breadth of topics within each module is such that no one person can adequately provide the information necessary to score all criteria within that module. The pilot test process revealed several opportunities for improving the usability of INVEST for a team of practitioners, many of which are reflected in Version 1.0. As a result of the Pilot Tests, the following features were developed and are now reflected in Version 1.0.

User Workspace

INVEST was created to serve as an important tool that has the potential to play a role in every agency's day-to-day working environment. During the Pilot Test, users suggested a feature that allowed them to develop their own password-protected private workspace, where multiple projects could be stored at various levels of completion.

To address this need, FHWA created a user workspace (Figure 3) that enables one user to store multiple projects. Due to privacy concerns, each workspace is accessible only with one username and password, but users are able to share this information with colleagues who need access to the same workspace. Most importantly, the process of scoring a project or program remains active, and a user can revisit any criterion within any module at any time.

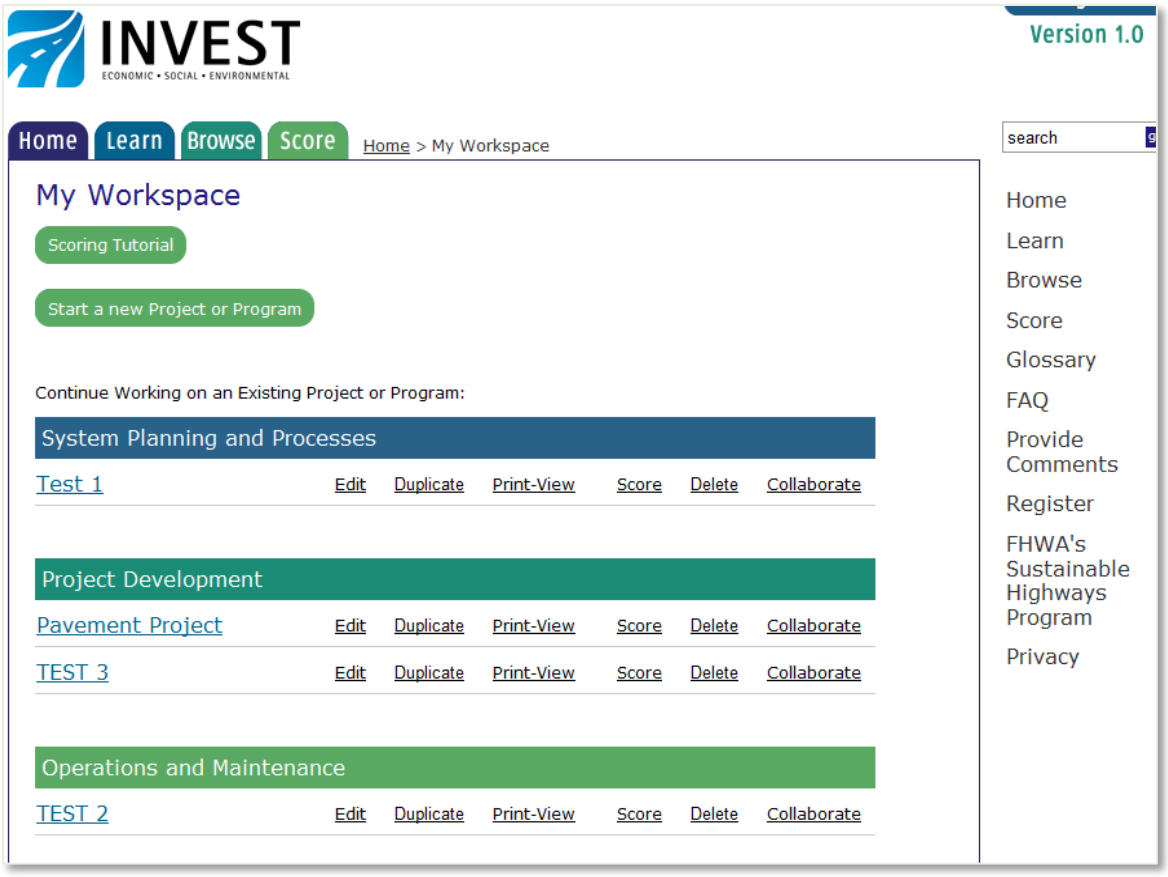

Figure 3: User Workspace
Source: http://www.sustainablehighways.org

Supporting Documents

The Supporting Documents feature allows users to upload supporting documents and store them within the tool. This feature is particularly helpful for criteria that rely on tracking material use or monitoring third party commitments. Furthermore, the documents remain attached to the relevant criteria and are available to be referenced by anyone with access to the user profile.

Scoring Notes

Similar to storing documents, users are also able to store notes that may be of use when criteria are revisited at a later date. This feature will be especially important if project management changes hands and a new manager needs to understand the rationale for how a particular criterion was scored. For example, scoring notes might indicate the rationale for scoring a question in a particular way, or what actions might be taken in order to improve a score.

Next Actions

Through the Next Actions feature, users can list the future tasks needed to improve the score for a criterion or appropriately document when the maximum number of points for that criterion is achieved. An agency that is revising its program could use INVEST – and the Next Actions feature in particular – to defend future recommendations and impact decision-making.

User Friendliness

The Pilot Test revealed simple improvements to the way that each criterion's information could be designed to improve usability and efficiency while determining the appropriate score. A redesign of the layout for each criterion now allows criterion details and scoring information to be located on the same page, eliminating the need to toggle back and forth between windows. FHWA also redesigned the "Sustainability Linkages" symbol to be more prominently displayed and directly referenced in the text.

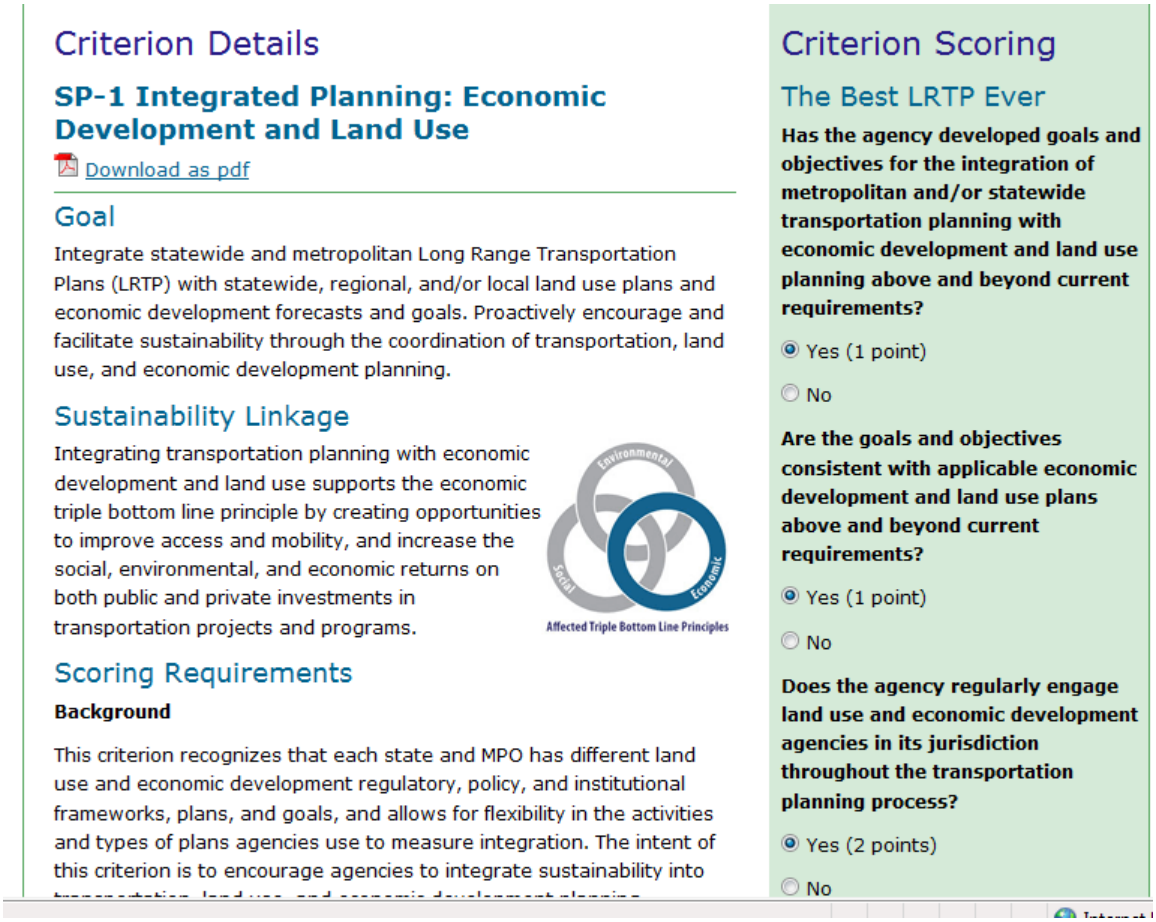

Figure 4: Criterion example
Source: sustainablehighways.org

Pilot Test Results: Flexibility

Several changes in the INVEST scoring process occurred as a direct result of the pilot tests.

Partial Credit

In an effort to allow for a more nuanced scoring process, opportunities for partial credit were built into many INVEST criteria. This allows agencies to capitalize on steps that have been made toward sustainable solutions, even when certain thresholds have not yet been met. Furthermore, most agencies achieved high scoring results with INVEST, and some agencies felt the final score was overly generous. Building in more opportunities for partial credit allows FHWA to develop a large range of scoring thresholds.

Project Development Scorecards

Testers suggested that the PD module, which is designed to evaluate specific highway projects, should be more flexible and customizable so that all types of highway projects have opportunities to score points. Based on this input, multiple scorecards for the PD module have been created, acknowledging differences in project setting and scope. Now, in addition to the basic and extended scorecards (which are based on project scope), there is an urban/rural option that takes setting into account. Furthermore, a separate paving scorecard is available for roadway resurfacing/rehabilitation projects. Finally, there is a new option to create a custom scorecard, though certain base criteria must be included in order to score a project (Figure 5).

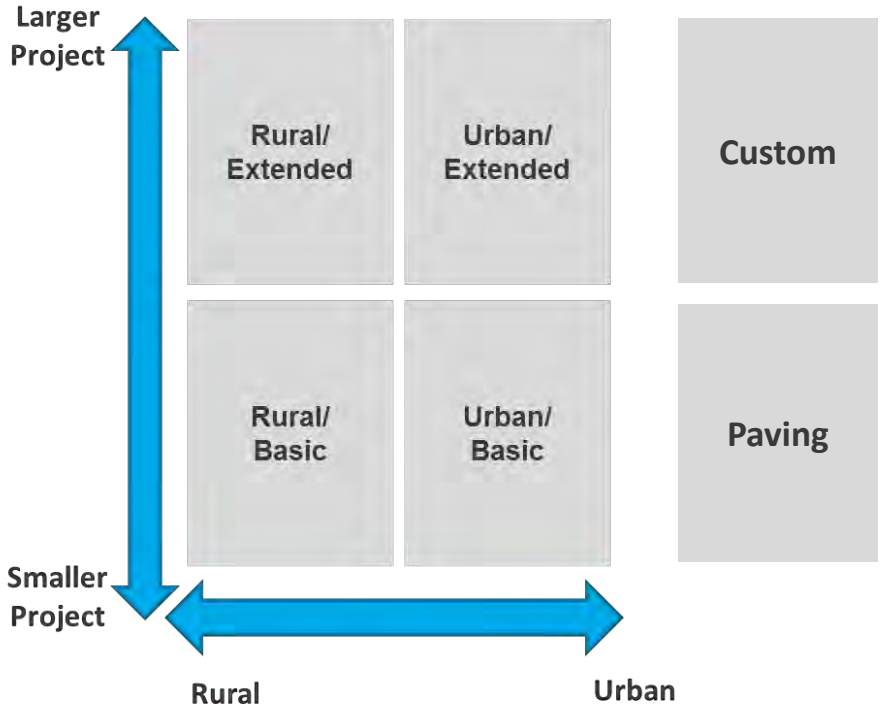

Figure 5: PD Module Types
Source: FHWA

EXAMPLE CRITERIA: ECOLOGY AND TRANSPORTATION

INVEST Version 1.0 consists of 60 individual criteria, including 17 SP (System Planning) criteria, 29 PD (Project Development) criteria, and 14 OM (Operations and Maintenance) criteria. While each criterion is an important component of the greater sustainability picture, several may be of particular interest to the ICOET community. This section provides an overview of those criteria with direct implications to transportation and ecology.

SP-01 Integrated Planning: Economic Development and Land Use
The goal of SP-01 is to integrate statewide and metropolitan Long Range Transportation Plans (LRTP) with statewide, regional, and/or local land use plans and economic development forecasts and goals. Agencies receive points based on their ability to:

- Develop and adopt goals and objectives,

- Engage partner agencies,
- Use best practice quantitative methods
- Provide leadership, and
- Demonstrate sustainable outcomes.

SP-02 Integrated Planning: Natural Environment
The goals of SP-02 are to (1) integrate ecological considerations into the transportation planning process (including the development of the long range transportation plan (LRTP) and TIP/STIP), and (2) to proactively support and enhance long-term ecological function through the coordination of transportation and natural resource planning. Points are accumulated based on an agency's ability to:

- Develop and adopt environmental goals and objectives,
- Engage natural resource and regulatory agencies,
- Apply system or landscape-scale evaluation techniques, and
- Demonstrate sustainable outcomes.

SP-10 Air Quality
The goal of SP-10 is to plan, implement, and monitor multimodal strategies to reduce emissions and to establish a process to document emissions reductions. Air quality issues are expected to be addressed based on the implementation of emissions reducing transportation strategies. The score is determined by an agency's ability to:

- Implement strategies to reduce emissions, and
- Conduct emissions analysis.

SP-16 Infrastructure Resiliency
The goal of SP-16 is to anticipate, assess, and plan to respond to vulnerabilities and risks associated with current and future hazards (including those associated with climate change) to ensure multi-modal transportation system reliability and resiliency. Points are accumulated with the following efforts:

- Identify hazards,
- Assess vulnerabilities,
- Assess risks, and
- Develop and implement adaptation strategies.

SP-17 Linking Planning and NEPA
The goal of SP-17 is to integrate transportation system planning process information, analysis, and decisions with the project-level environmental review process, and reference it in NEPA documentation. Points are awarded on a cumulative basis when agencies:

- Document linkages between transportation system planning and NEPA,
- Consult NEPA practitioners, and
- Apply system planning results to NEPA projects.

PD-07 Habitat Restoration
The goal of PD-07 is to avoid, minimize, and compensate the loss and alteration of natural (stream and terrestrial) habitat caused by project construction and/or restore, preserve, and protect natural habitat beyond regulatory requirements. Points are scored depending on the level to which an agency:

- Minimizes impacts to habitat,
- Avoids impacts to habitat, or
- Enhances features that promote habitat restoration.

PD-08 Stormwater
The goal of PD-08 is to improve stormwater quality due to any negative impacts resulting from the project and control flow to minimize their erosive effects on receiving water bodies and related water resources, using management methods and practices that reduce the impacts associated with development and redevelopment. An agency scores points based on the level of management in each of the following areas:

- Water quality,
- Flow control, and
- Management techniques that mimic natural hydrology to treat pollutants.

PD-09 Ecological Connectivity
The goal of PD-09 is to minimize, avoid, or enhance wildlife, amphibian, and aquatic species passage access and mobility, and reduce vehicle-wildlife collisions and related accidents. In order to score this criterion, the agency must conduct a prerequisite site-specific ecological assessment of the roadway project using GIS data or regional expertise. Points are scored depending on the level to which an agency:

- Minimizes impacts to connectivity,
- Avoids impacts to connectivity,
- Enhances connectivity features, and/or
- Restores connectivity features.

PD-18 Site Vegetation
The goal of PD-18 is to promote sustainable site vegetation within the project footprint that does not require long-term irrigation, consistent mowing, or invasive/noxious weed species removal. In order to score this criterion, the agency must meet the prerequisite that all site vegetation uses only non-invasive species, non-toxic species, and seeding that does not require consistent mowing for a viable stand of grass, all while minimizing disturbance of native species. Once the prerequisite is met, points are cumulatively scored based on the following features:

- Non-mechanical maintenance,
- No long-term irrigation,
- Greywater or reclaimed water irrigation,
- Native species, and
- Long-term vegetation planning.

OM-09 Maintenance Management System
The goal of OM-09 is to leverage a Maintenance Management System (MMS) to inventory, assess, analyze, plan, program, implement, and monitor maintenance activities to effectively and efficiently extend the life of the system, improve the service, and reduce the impacts to the human and natural environment. An MMS is a computerized database that is designed to integrate an agency's asset management and maintenance management systems in order to optimize the management of maintenance. Based largely on AASHTO's "Guidelines for Maintenance Management Systems" (GMMS), an agency accumulates points based on the extent to which they:

- Integrate certain elements of MMS,
- Integrate vehicle-based technology as part of the MMS,
- Develop a fully integrated MMS,
- Leverage the MMS to define projects, and
- Perform maintenance quality assurance.

OM-12 Road Weather Management Program
The goal of OM-12 is to plan, implement, and monitor a road weather management (including snow and ice control) program to reduce environmental impacts with continued or better level of service. A successful road weather management program supports improving safety, increasing mobility, reducing delay and traffic interruptions, increasing productivity of the labor force, and reducing impacts of materials used for management on the human and natural environments. To score points cumulatively, an agency must:

- Develop a road weather management program,
- Set goals and monitor progress,
- Implement a road weather information system,
- Implement the standards of practice for snow and ice control,
- Implement a materials management plan, and/or
- Implement a maintenance decision support system.

INVEST IN ACTION

Several transportation agencies around the nation are using INVEST to learn more about best practices in sustainability and track progress where sustainability efforts have been implemented. Using some of the above criteria as examples, this section illustrates how an agency evaluated their level of sustainability in that area, how the agency scored on the criterion (including justification and sources of documentation), and how the agency improved sustainability practices by learning from the INVEST evaluation and identifying cost effective opportunities for implementation.

SP-1 Integrated Planning: Economic Development and Land Use

The North Central Texas Council of Governments (NCTCOG), one of the agencies that pilot tested INVEST, scored well on this criterion, but found through the INVEST self-evaluation that there was room for enhancing their work in this area in such a way that would both improve sustainability outcomes, and help the agency take more credit for the good work it was already doing. Leveraging internal staff expertise, NCTCOG assembled staff responsible for developing the long range transportation plan (LRTP) as well as subject matter experts on particular areas such as bicycle and pedestrian improvements and transit-oriented development. Staff reviewed the criteria, gathered data and documentation, and conducted a scoring workshop to develop scores. A total of up to 15 points are available for this criterion.

Evaluate and Score

Develop and Adopt Goals and Objectives (2 points) NCTCOG gained both points available. NCTCOG's policy board adopted policies on how to prioritize sustainable development projects, as outlined in the LRTP. This includes policies for utilizing existing system capacity, improving rail mobility, promoting mixed use development, and improving access management.

Engage Partner Agencies (3 points) NCTCOG collected all three points in this area as it works closely with the full range of partners in the area, including local governments, counties, the Texas Department of Transportation, and area transit agencies. It also utilizes institutional mechanisms such as the Bicycle and Pedestrian Advisory Committee to facilitate engagement, as specified in the criterion.

Use Best Practice Quantitative Methods (2 points) NCTCOG gained partial points for using best practice quantitative methods. NCTCOG uses a best-practice transportation model (Dallas-Fort Worth

Regional Travel Model) to analyze and evaluate the performance of alternative land use/transportation policies and scenarios. They also use an integrated land use model called G-LUM (Gravity Land Use Model), though it is not considered a best-practice model.

Provide Leadership (2 points) To support scoring two points, NCTCOG cited its robust Sustainable Development Funding Program, through which it has allocated over $120 million in funding through three calls for projects in 2001, 2006, and 2011.

Demonstrate Sustainable Outcomes (6 points) NCTCOG did not score points on this criterion. For future improvement, NCTCOG plans to focus on this final sub-criterion, which offers six points for developing sustainability performance metrics, tracking these metrics, and demonstrating achievement.

Improve

NCTCOG realized that they were performing well in economic development and land use, but that it would be to their advantage to better document and measure outcomes. As NCTCOG begins work on their next LRTP, they plan to focus on developing sustainability performance measures. As the agency has allocated millions of dollars through sustainability-related programs, NCTCOG aims to quantify the benefit of these programs at meeting sustainability and mobility goals such as air quality and reduced congestion.

NCTCOG plans to conduct work in four phases:

- Phase 1. Performance Measure Assessment – Identify possible performance measures using resources recommended by INVEST and examining measures used by other transportation agencies. Additionally, NCTCOG will evaluate data availability and assess efforts outside of the metropolitan transportation planning process that could support performance measure development.
- Phase 2. Performance Measure /Objective Development - Develop SMART (Specific, Measurable, Achievable, Realistic, Timely) objectives and performance metrics for desired System Planning Criteria.
- Phase 3. Integration into the Metropolitan Transportation Planning Process - Collect and analyze appropriate data. Identify and involve stakeholders and appropriate committees for technical and public input.
- Phase 4. Document results of performance measures in the Metropolitan Transportation Plan - Incorporate SMART objectives and performance measures into the metropolitan transportation planning phases.

PD-8 Stormwater

The Cleveland (Ohio) Innerbelt Bridge project provides an example of scoring and documenting the INVEST Stormwater criterion. Projects receive up to three points in each of three categories (water quality, flow control, and low-impact development) for a total possible score of nine points.

Evaluate and Score

Water Quality (1-3 points) The score for water quality requires treating pollutants from at least 80 percent of the total annual runoff volume. The table below is then used to calculate the number of points achieved. The Cleveland Innerbelt Bridge project received the maximum of three points for this sub-

criterion as it treats greater than 90 percent of the annual runoff volume of sediments, metals, and other pollutants. The target impervious surface area treated is greater than 125% of the impervious surface area added.

These outcomes are particularly important as the Innerbelt project is located in a combined stormwater-sewer area. The project was designed to separate stormwater from combined sewers at feasible locations and treat the separated runoff by an Ohio DOT -approved best management practice. Using project documents, staff tracked exactly how many acres of drainage area would be treated using different methods.

The total pre-project area that drained to the combined sewer was 58 acres. The Innerbelt Bridge project separated 20 acres of area that previously drained to the combined sewer system and rerouted these areas to manufactured systems and extended detention basins designed to best management practices from the Ohio DOT Location & Design Manual Volume 2. The remaining 38 acres will stay connected to the combined sewer and will receive treatment at a wastewater treatment facility.

TABLE 1. WATER QUALITY – REDEVELOPED ROADWAYS

(1)	(2)	(3)	(4)
Amount of Runoff Treated (% of Annual Volume)	**Target Pollutant**	**Target Imp. Surface Area (% of Added)[1]**	**Points**
80–89%	Sediment	101%–125%	0
		>125%	1
	Sediment, and Metals or Other [2]	101%–125%	1
		>125%	2
90% +	Sediment	101%–125%	1
		>125%	2
	Sediment, and Metals or Other [2]	101%–125%	2
		>125%	3

Column 3 – For retrofit projects, see Table 2 for equivalent percentages to use.

1 – % of Added = Treated Impervious Surface Area ÷ Added Impervious Surface Area

2 – Other basin-specific pollutant of concern is targeted

Flow Control (1-3 points) Flow Control requires managing the flow from at least 80 percent of the total runoff volume, and is based on controlling durations and attenuating peak flow magnitudes from the project site. The table below is used to calculate the number of points achieved for flow control based on the amount of runoff treated, materials treated, and the target impervious surface area treated.

Ohio DOT designed the stormwater system to control 100 percent of peak flows for the 5, 10, and 25 year flows. Controlling peak flows from storm events reduced the probability of overflowing the system and discharging sewage directly to the Cuyahoga River. Peak flows were managed through detention and water quality treatment for all separated areas that discharge directly to the Cuyahoga River. Data from the tables from the E. 9th Street, Gateway, E.22nd, and Tremont Roadway Reports for the Cleveland Innerbelt Bridge Project show pre/post flows to area tributaries and combined and separated sewers. According to this data, over 125% of the target impervious surface area is treated for flow durations. This

places the project's performance on the final line of the table below, earning the project all three points for this sub-criterion.

TABLE 3. FLOW CONTROL

(1) Amount of Runoff Managed (% of Total Volume)	(2) Flow Control Standard Used	(3) Target Imp. Surface Area (% of Added) [1]	(4) Points
80–89%	Peak Rate	101%–125%	0
		>125%	1
	Flow Durations	101%–125%	1
		>125%	2
90% +	Peak Rate	101%–125%	1
		>125%	2
	Flow Durations	101%–125%	2
		>125%	3

Column 3 – For retrofit projects, use Table 2 for equivalent percentages.

Low Impact Development / Effective Best Management Practices (1-3 points) Best management practices for stormwater management mimic natural hydrology to treat pollutants and include detention ponds, wet ponds, wetlands, biofilters, and media filters. The Innerbelt project received the maximum of three points for this area as 100 percent of impervious surface area is treated using best management practices. All 20 acres separated from the combined sewer and 6.3 acres from East Bank & W.3rd Street are being treated per Ohio DOT's Location and Design Manual Volume 2. The remaining 38 acres will stay connected to the combined sewer for treatment.

Documentation The scoring team attached Tables from the E. 9th Street, Gateway, E.22nd, and Tremont Roadway Reports for the Cleveland Innerbelt Bridge Project in order to show pre/post flows to area tributaries and combined and separated sewers.

Improve

Through the INVEST evaluation process, Ohio DOT learned that this project demonstrated a strong commitment to stormwater management. They also learned as the project progressed that ground-truthing is required, because even with the extensive analysis conducted ahead of time to improve stormwater management, on the ground realities can reveal additional challenges that need to be addressed.

OM-12 Road Weather Management Program

The Utah Department of Transportation (UDOT) evaluated their Operations and Maintenance program with the Pilot Test version of INVEST, and Road Weather Management was one criterion for which the agency performed particularly well. There are fifteen total points available for this criterion spread across six sub-criteria.

Evaluate and Score

Develop a Road Weather Management Program (2 points) A Road Weather Management Program (RWMP) includes strategies that can be used to mitigate the impacts of rain, snow, ice, fog, high winds, flooding, tornadoes, hurricanes, avalanches, and other inclement weather on traffic.

UDOT gained both points available. UDOT's RWMP has been a major component enabling the agency to maintain a uniform level of expenditures even with expanding facilities. Whereas one truck used to plow one lane, a single truck can now plow three lanes, using wing plows that widen the right and left sides and a tow plow that removes additional snow. UDOT also increased the capacity of their trucks so that trucks can be out for 2 ½ hours rather than 90 minutes. UDOT's RWMP is extremely iterative, and the agency is continuously refining its programs as it is learning. The RWMP emphasizes weather forecasting and preparation. Best management practices are tailored for the different climatological regions of the state.

Set Goals and Monitor Progress (3 points) UDOT received points for having established quantifiable performance metrics based on level of service, amount of materials used and other relevant parameters. UDOT also received an additional point for monitoring progress towards goals for at least one year and showing measurable advancement towards stated goals. UDOT sets performance goals for each road section and monitors conditions hourly during storms, providing regular updates to the public.

Implement a Road Weather Information System (3 points) Roadway Weather Information Systems (RWIS) are a way to monitor pavement and weather conditions in real-time using sensors to measure atmospheric, pavement, and/or water level conditions. This data allows the operator to make the best decisions about how to respond, for example, when to apply chemicals, how much to apply, and what type of chemical to apply, thereby reducing the amount of salt and chemical applied and increasing its effectiveness. UDOT scored all three points in this area. UDOT plow trucks are equipped with road pavement sensors. This allows truck operators to make adjustments to chemical application while they are on the road. UDOTs' road condition cameras, fixed RWIS stations, and mobile RWIS all feed information into traffic management and operations decisions. This has enabled the agency to reduce operating costs and speed response times.

Implement the Standards of Practice or Standard Operating Procedure (SOP) for Snow and Ice Control (2 points) An agency receives one point for having an RWMP that includes, at a minimum, the following elements specific to snow and ice control:

- Reducing salt use in environmentally sensitive areas
- Existence of an anti-icing program
- Conducting periodical training program for proper use of salt and chemicals
- Best Management Practice (BMP) for chemical storage facilities
- Proper storage of chemical and chemical-abrasive stockpiles
- Proper calibration of equipment
- Reducing cost and improving fuel efficiency by planning and optimizing routes

An agency receives an additional point if the agency's program includes performance standards that take into account sustainability, and demonstrate a reduction in materials and truck fuel usage.

UDOT received the maximum score. This area highlights all three of the sustainability triple bottom line principles.

UDOT's snow removal practices:

- save $124,000 per year compared to standard practice (economic)
- reduce the amount of salt used by 30 percent (environmental)
- improve road safety and accessibility (social)

These practices include the implementation of slurry spreaders which reduce the amount of salt required, gravity flow brine tanks that decrease the need to pump, and the installation of snow fences that block snow from drifting across lanes. UDOT also carefully manages chemicals at storage sites and refrains from using salt when temperatures are low enough that plowing alone is sufficient.

Implement Materials Management Plan (2 points) An agency receives two points for successful implementation of a Materials Management Plan to monitor quantities of salt applied and level of service during and after an event; includes salt, chemicals, sand, etc. As noted above, UDOT monitors levels of salt applied and levels of service.

Implement a Maintenance Decision Support System (3 points) An agency receives up to three points for developing a Maintenance Decision Support System (MDSS) to improve the effectiveness and efficiency of roadway weather treatments and implement best practices. An MDSS uses atmospheric weather modeling and generates recommendations for road treatment based on sensor readings from road locations. UDOT was not able to receive points under this criterion because they chose not to implement an MDSS. UDOT made this decision because the large geographic scale and computer based algorithms of an MDSS do not work well for the complex weather patterns and micro climates Utah experiences due to its mountainous and varied topography. UDOT has found that its own system actually outperforms an MDSS and costs less. UDOT's own system takes into account wind, sensitivity to micro climates, three different convergence zones, and lake effects.

Scoring Sources and Documentation Documentation included the Road Weather Management Program, the Road Weather Information Systems, and progress reports on performance metrics. The Road Weather Information System data is made available to the public at http://udottraffic.utah.gov/RoadWeatherForecast.aspx.

Improve

As discussed earlier, after scoring their operations and maintenance program, UDOT developed a prioritized set of recommendations for improved sustainability. UDOT listed as medium priority a recommendation to produce a snow removal decision support system, which would essentially formalize the agency's current process. The excerpt below summarizes the recommendation:

Recommended Action: Produce a Snow Removal Decision Support System.
Benefit(s): Best use of resources by using the appropriate amount of material and equipment.
Responsible Division: Maintenance
Relation to Sustainability: Using the proper amount of material (salt, red salt, etc.) is vital to keeping the roads safe during storms. Excess use wastes resources (material and money) as well as introducing more salt to the environment.
Effort/Cost: Although each storm is unique, guidelines regarding best practices (including type and amount of material; use of brine; time between plow passes; etc.) are available and should be implemented. Performance measures should also be established.
Ease of Implementation: Measuring snow removal performance has always been difficult. The shed crews take great pride in their plowing efforts. Extensive, continuing education will be required to follow best practices.

NEXT STEPS

FHWA's ultimate goal is to improve the sustainability triple bottom line – social, economic, and environmental outcomes – of highway programs and projects. To further this goal, FHWA is currently in the process of encouraging transportation agencies across the country to implement INVEST. As appropriate, financial support is being made available (again, with a 100% agency match) to ensure agencies are equipped with the resources necessary to successfully implement the tool. As with the pilot test process, FHWA will ask agencies to provide detailed information about how INVEST is being used and how it is impacting decision-making. As FHWA establishes a broader collection of case studies and best practices in evaluating and improving highway sustainability, these examples can be shared with other agencies interested in how sustainability can be integrated into their projects and programs. Finally, FHWA seeks the continuous improvement of INVEST and requests feedback on further enhancement of the tool. This information will be collected and incorporated wherever possible into INVEST Version 2.0.

FHWA has also recently embarked on a research project to help identify, quantify, and describe cost savings from the use of sustainable practices in highway planning, design, construction and maintenance. The study will investigate cost savings related to materials, supplies, and other resources; energy consumption; capital for infrastructure development; and elimination or reduction of certain operation and maintenance practices. This effort is intended to be used to help make a business case for sustainable highways and to identify a set of practices to promote for consideration in other State highway programs.

To learn more about INVEST 1.0 or to try out the tool, visit http://www.sustainablehighways.org. In addition to INVEST, FHWA has also created a Sustainable Highways Initiative to educate stakeholders about sustainable practices and promote their use in the Federal-aid and Federal Lands Highway programs. Information about the Sustainable Highway Initiative can be found at http://www.sustainablehighways.dot.gov/.

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BIOGRAPHICAL SKETCH

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