Innovative Partnerships Help Inventory Traffic Signs

A win–win: University students gain real-world experience working on transportation projects with local public agencies that have limited resources.

by Seri Park, Leslie Myers McCarthy, John McFadden, and George Merritt

(Above) Villanova University students are using a retroreflectometer to measure sign retroreflectivity and assigning numerical values to recommend whether a sign replacement is necessary. *Photo: Dr. S. Park, Villanova University.*

In recent years, State departments of transportation (DOTs) and local public agencies have faced the challenges of shrinking budgets and reduced staffing to conduct the business of supporting transportation programs. At the same time, universities are taking steps to integrate relevant, real-world experience into their curricula to better prepare undergraduate and graduate students to hit the ground running once they enter the transportation workforce. In fact, many universities have embraced the idea of collaboration between academia and the public sector as a means to benefit both parties during a time of limited resources.

Villanova University in southeastern Pennsylvania recently put this type of collaboration to the test, forming an ongoing partnership with five nearby municipalities. Starting in 2009, Villanova students interested in transportation engineering conducted several projects, under the advisement of university faculty, designed to address the needs of the five local transportation agencies. The projects included studies regarding traffic impacts, signal coordination, and infrastructure capacity.

One project in particular focused on a methodology to develop local inventories of traffic signs. The inventories are a tool that municipalities can use to help them comply with Federal Highway Administration (FHWA) requirements for minimum levels of sign retroreflectivity, as outlined in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD). The goal was to develop an inventory database that public agencies, including local DOTs, could use to manage their signing assets, ultimately leading to improved compliance with retroreflectivity standards.

The partnership between the university and the local DOTs resulted in an innovative approach to resolving a real transportation need while engaging students in a constructive manner to achieve the solution.

"Exposing students to real-world transportation projects helps them accelerate through the learning curve they face after graduation and joining the workforce," says Greg Schertz, FHWA retroreflectivity team leader. "Incorporating relevant learning activities into civil engineering coursework can better prepare them for jobs and increase the likelihood of employee retention once they join the workforce."

Understanding the Problem

According to FHWA, about half of all traffic fatalities occur at night, while only about one quarter of travel occurs after dark. Although intoxication and fatigue contribute to the high rate of nighttime crashes, driving in darkness is inherently hazardous because of decreased visibility. Retroreflectivity helps improve safety by bouncing light off of road signs from vehicle headlights back toward drivers' eyes, making signs appear brighter and easier to read. However, retroreflective properties deteriorate over time, so DOTs need to monitor and maintain their signs to ensure that they remain clearly visible at night.

In the early 1990s, Congress passed a law requiring the Secretary of the U.S. Department of Transportation to establish minimum retroreflectivity standards for traffic signs. After years of research and public involvement, FHWA published standards in the 2009 edition of the MUTCD. By establishing that transportation agencies must consider the performance of signs under their jurisdiction, the requirements help ensure drivers can see signs at night.

Agencies developing programs to manage traffic signs face considerable challenges determining how to track the total number of signs; location of each sign; the color, shape, and age; and retroreflective performance. These challenges represent a considerable change in the way agencies historically have managed their traffic sign assets. Developing traffic sign inventories has proven an important tool to help agencies manage their signs.

The Need for Sign Inventories

As reported in *National Cooperative Highway Research Program (NCHRP) Synthesis 431: Practices to Manage Traffic Sign Retroreflectivity*, many DOTs have acknowledged the value of establishing a sign inventory to help maintain their signs and ensure that they are visible at night.

A review of studies related to sign retroreflectivity suggests that

These day and night photos show the same freeway guide sign. The number "5" was replaced recently and appears much brighter than the other words, which are much older. *Photos: Dr. S. Park, Villanova University.*

Vanvi Trieu, Villanova University

This student is inspecting the positioning of a sign as part of a sign inventory for Radnor Township, PA. Inspection data coded in the sign inventory system support the township in better managing its roadway assets.

public agencies can use a sign inventory database to help manage their risk associated with the potential liability resulting from traffic crashes that occur at locations where signs did not meet retroreflectivity standards. According to the Institute of Transportation Engineers' *Traffic Signing Handbook*, results from a highway tort liability study in Pennsylvania showed that sign deficiencies were cited as "the principal factor in 2 [percent] of the sampled tort actions, second only to pavement deformities." Further, the study found that in 41 percent of crashes involving a fatality or serious injury, sign deficiencies were cited as the primary cause.

NCHRP Synthesis of Highway Practice 157: Maintenance Management of Street and Highway Signs recommends that DOTs use a detailed field inventory to identify deficient signs, and prioritize and schedule maintenance activities. R.L. Carstens' "Highway Related Tort Claims to Iowa Counties" (published in *Transportation Research Record* No. 833) indicates that a sign inventory is essential in proving the existence of a particular sign in a particular location at a specific time. The study goes on to say that an inventory can serve as a mechanism for documenting conformance with standards and logging updates as signs are added, removed, or replaced.

In addition to underscoring the legal implications of signs' compliance with retroreflectivity requirements, FHWA's *Maintaining Traffic Sign Retroreflectivity: Impacts on State and Local Agencies* (FHWA-HRT-07-042) shows the vital role that standard traffic control signs play in ensuring efficient and safe flow of traffic. "Evaluation of a Low-Cost Program of Road System Traffic Safety Reviews for County Highways" (*Transportation Research Record* No. 1819) also suggests that perhaps the most cost-effective countermeasure for enhancing traffic safety is to upgrade signs to meet the current standards for retroreflectivity and other features, such as sign height and letter size.

As reported by R. Troutbeck and J. Wood in their 1994 article "Effect of Restriction of Vision on Driving Performance," published in the *Journal of Transportation Engineering*, vision provides more than 90 percent of the information used in driving tasks. With Americans living longer and continuing to drive later in life, well-maintained traffic control signing is more important than ever for keeping drivers alert and informed.

Establishing an Effective Partnership

Like many academic institutions, Villanova University emphasizes community service through its various engineering activities. One example of this approach is the university's efforts to support nearby local public agencies by conducting transportation service projects. These partnerships not only help prepare students to apply theoretical knowledge in a real-world setting, they also benefit the local agencies by providing engineering services at no cost.

Projects performed in collaboration with the public sector by Villanova University's faculty, who are licensed professional engineers, and students have included traffic impact analyses, intersection signal coordination and level-of-service analyses, and the development of tools for managing infrastructure assets. To date, these academic service projects have benefitted the Delaware Valley Regional Planning Commission and a handful of municipalities in southeastern Pennsylvania, specifically Radnor, Tredyffrin, Upper Darby, West Bradford, and West Pikeland Townships.

For example, Dylan White, a senior at Villanova University, is developing a comprehensive pavement management database for Upper Darby Township using traditional condition inspection techniques and nondestructive testing with Villanova's spectral analysis surface wave equipment. White states, "Investigating the reliability and accuracy of the nondestructive evaluation equipment is an exciting challenge with the potential to help municipalities reliably, quickly, and economically test their roadways."

Upon completion of the projects, students present their deliverables, which include written final reports describing results along with inventory databases (such as traffic sign inventories and pavement management data) developed in Microsoft® Excel® for easy implementation by the townships. The deliverables also include recommendations to the public agencies and other project stakeholders.

Proposed Sign Inventory

In the case of the collaboration to develop a sign inventory system, the goals were threefold. First, the partnership would result in the development of a database that would provide the municipalities with an inventory of their regulatory signs and retroreflectivity values. Second, the faculty at Villanova University would accomplish their mission of providing an opportunity for students to conduct state-of-the-art, real-world research. Third, the students would gain first-hand experience working on a timely topic in the field of transportation engineering in collaboration with partners in the public sector.

The objective was to develop a sign inventory system while also integrating traffic operational parameters, such as crash and exposure data, to explore criteria for prioritizing sign inspections when agencies are unable to collect data from the entire population of signs. In general, the process included three major steps: (1) assessing available resources, (2) establishing a tiered ranking system and identifying signs that play a critical role in safety, and (3) measuring retroreflectivity and collecting other data for the sign inventory.

Step I: Analysis of Available Resources

The faculty and students at Villanova worked with each of the local public agencies, which are within approximately a 30-mile (48-kilometer) radius of the university, to analyze their financial and staffing situations to determine the resources available to support a sign inventory. For example, some of the municipalities do not have engineering departments and are limited in both staffing and budget. Subsequently, the researchers compared the size and scale of the available resources to develop a suitable process that any local agency could follow to develop a sign inventory.

Next, the research team reviewed the relevant data available from each agency, including annual average daily traffic, crash data and related roadway geometrics (for example, whether crashes occurred at intersections or midblock), and the presence and type of traffic control devices. Traffic counts were unavailable for some of the local roads.

Because crash data were available for all of the municipalities, the researchers applied crash analysis in defining tier levels. Note that the specific process for assigning a tier level and selecting threshold values for crash frequencies might not be applicable to other State or local agencies where the level of resources and the size of the jurisdictions might be significantly greater.

Step II: Tier Definition And Assignment

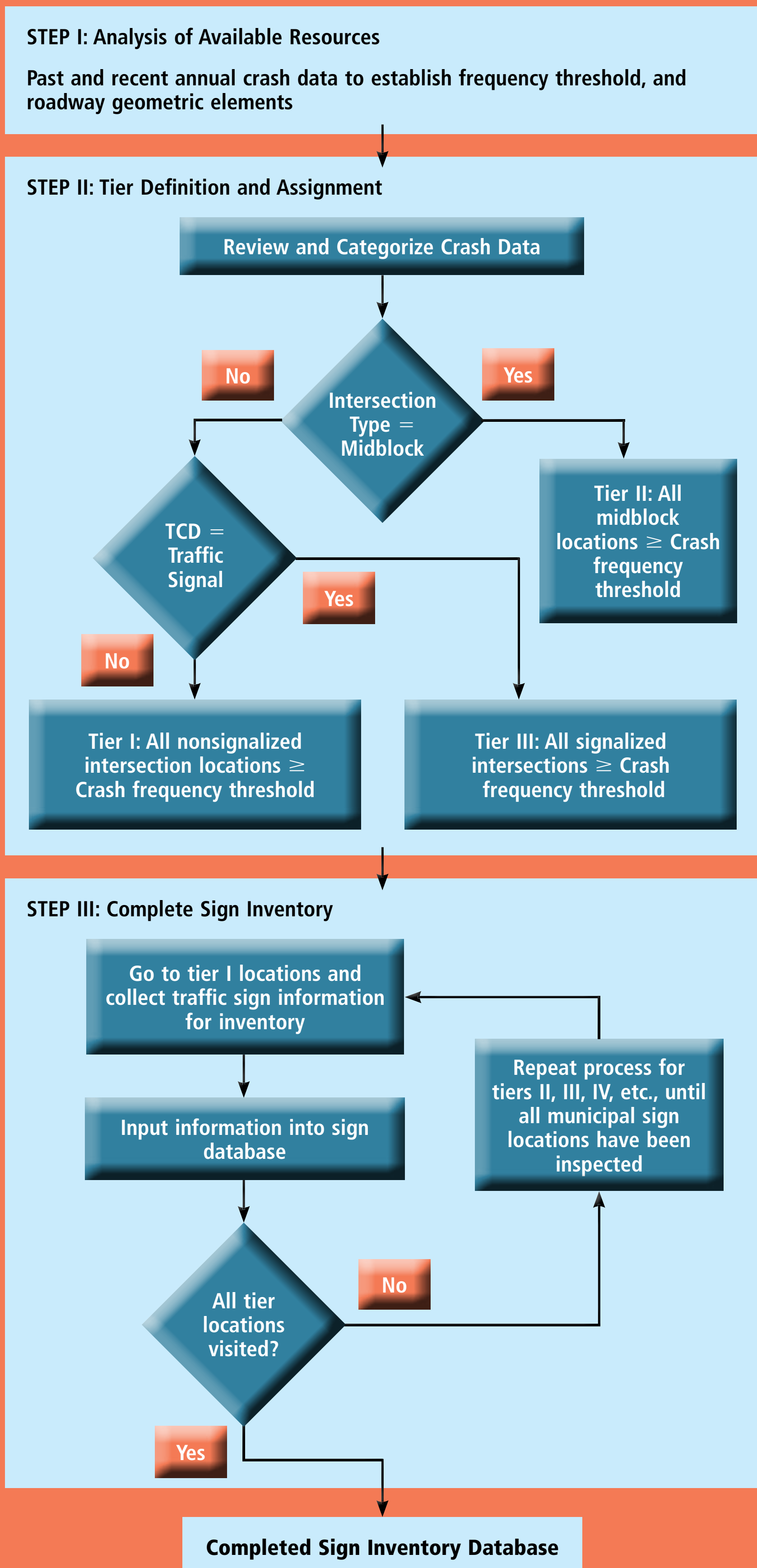
The research team determined that a tiered system would be the most effective way to streamline the collection of data for agencies that do not have existing sign inventories. The proposed tier system focuses on classifying signs into groups based on crash data and thereby prioritizing the locations for collecting data. By assigning traffic signs to tiers of importance as they relate to safety, the agencies could prioritize the signs to inventory first. Over time, the agencies can continue to collect data on sign attributes until they have recorded all sign assets for an entire jurisdiction.

The researchers determined the levels and criteria for tier

Dr. S. Park, Villanova University

These students are conducting traffic counts at an intersection as part of a traffic impact analysis for Radnor Township, PA.

Flowchart of Sign Inventory Development Process



Source: Leslie McCarthy, Seri Park, and John McFadden.

categorization based on a comprehensive screening of the data. They assigned a crash frequency threshold for each tier-level assignment specific to each jurisdiction, which was determined in conjunction with each agency through analyzing the number of locations that produced different crash values.

Using this approach, tier I represents the locations where signs are the primary source of traffic control and where the localized history of crashes exceeds a frequency threshold selected by the agency. Thus, tier I assignments include regulatory signs at nonsignalized intersections. With this approach, public agencies can focus on signs sequentially, ensuring that they inventory at the highest priority locations first.

The numbers and types of traffic control devices, along with the roadway functional classifications (local, collector, or arterial roadways), contributed to determining a sign's tier assignment. Thus, the agencies classified the signs as tier II or III where they identified crash record locations as midblock or at signalized intersections, respectively, while still exceeding the crash frequency threshold set by the local agency. The researchers developed the remaining tiers based on the type of sign (warning, guide, or informational) and the roadway classification.

After assigning all locations to a tier level, the researchers marked the locations on a map, and the university students proceeded to collect detailed information on the regulatory and warning signs at those spots. While onsite, the students inspected each sign for compliance with several elements of the MUTCD, including retroreflectivity level and the signpost's distance from the edge of the pavement.

Step III: Complete Sign Inventory

The students developed the sign inventory database to be a living tool that the agencies can use over time in assessing and replacing signs or other assets. They designed the database to meet the recommendations outlined in the American Association of State Highway and Transportation Officials' *Asset Management Data Collection Guide* (2006), which calls for inclusion of attributes such as sign type, age, and height; number

Attributes of Participating Local Public Agencies

Radnor Township, PA	Tredyffrin Township, PA	West Bradford Township, PA	West Pikeland Township, PA
• Suburban • 2010 census population: 31,531 • 13.8-square-mile (35.7-square-kilometer) land area • 93 lane-miles (150 kilometers) of municipal roads • Multiple business districts • Police department • Previous 3 years of crash data with the following details: — Date — Crash severity — Intersection type — Principal road — Intersecting road — Traffic control device	• Suburban • 2010 census population: 29,332 • 19.8-square-mile (51.2-square-kilometer) land area • 106 lane-miles (171 kilometers) of municipal roads • Multiple business districts • Police department • Previous 3 years of crash data with the following details: — Date — Intersection type — Principal road — Intersecting road — Traffic control device	• Rural • 2010 census population: 12,223 • 18.5-square-mile (47.9-square-kilometer) land area • 64 lane-miles (103 kilometers) of municipal roads • Previous 3 years of crash data with the following details: — Date — Address	• Rural • 2010 census population: 4,024 • 9.9-square-mile (25.6-square-kilometer) land area • 34 lane-miles (55 kilometers) of municipal roads • Previous 2 years of crash data with the following details: — Date — Address

This table summarizes the attributes and available traffic operational parameters used to determine the appropriate level of sign prioritization and a strategy for data collection and analysis.

of panels; post material; and year of installation. The retroreflectometer that the students used enabled them to collect a significant number of sign-related attributes, including each sign's GPS coordinates.

After reviewing similar database tools produced by Local Technical Assistance Program offices, the researchers built their database to run on the Microsoft® Excel® platform so that it can easily integrate into each agency's existing asset management system. For example, at the State level, the Pennsylvania DOT's Sign Inventory and Management Program also exists in Excel file format.

Level of Effort

To provide an estimate of the level of effort required to produce this type of sign inventory system, the researchers documented the time required to complete the collection of tier I sign data in Radnor Township, PA. For one civil engineering student, collection and interpretation of crash data took about 25 hours, field measurement of retroreflectivity using a handheld retroreflectometer and the collection of other data took about 15 hours, and input of the field data into the sign inventory database took about 20 hours, for a total of 60 hours. Thus, it took just under 2 weeks to complete the crash data analysis, field measurements, and data entry for 86 tier I signs in Radnor Township, which was the largest of the four municipalities.

The development time reported represents the initial investment of reviewing incident data, measuring sign retroreflectivity with a handheld device, and entering sign data into an Excel spreadsheet. In the majority of cases, this initial step is also the most time consuming. Looking forward, the townships now can maintain the inventory over time and make updates to the spreadsheet as they replace failing signs, build new countermeasures, or notice a change in the conditions of existing signs.

The inventory method developed by Villanova's faculty and students helped provide four Pennsylvania townships with a key tool that will be used to comply with the MUTCD and minimum retroreflectivity standards. The method also established a way forward for ongoing updates to each agency's sign database.

Using academic service projects to overcome the barrier of limited funding could serve as a model for establishing comprehensive and sustainable sign inventory databases such as those called for in *NCHRP Synthesis 431: Practices to Manage Traffic Sign Retroreflectivity.* Each of the townships has been able to take strategic remedial action in replacement of key failing signs by directly using the sign inventories developed by Villanova students. As previously described, the database includes regulatory and warning signs at locations with a history of crashes and a lack of other traffic control devices. Even if the signs did not fail the retroreflectivity requirements, they may have had other deficiencies such as deteriorated signposts, signs without breakaway posts, and graffiti or vegetation overhang. This project enabled the municipalities to strategically remedy only the signs that needed addressing rather than unnecessarily wasting resources doing blanket replacements.

"Because a sign inventory is a living tool," says Carl K. Andersen, leader of the Roadway Team, FHWA's Office of Safety Research and Development, "it is critical that the tiered rating of a sign be updated and reclassified when replacement or repair occurs, or when other safety countermeasures are added to the roadway."

It is intended that Villanova students will periodically assist the four townships in updating the sign inventories. This will be done either through a service project as part of Villanova University's student chapter of the Institute of Transportation Engineers or as part of an undergraduate independent study in civil engineering in which a student receives course credits.

A Win–Win Collaboration

By leveraging the resources of academic institutions, local and State agencies can overcome shortages of human and financial resources, while offering students hands-on experience solving real-world transportation problems.

"In a time of diminishing resources and increased mandates, our partnership with Villanova University's Department of Civil & Environmental Engineering helped us make significant headway toward meeting the new Federal requirements in a cost-effective way," says Vincent Visoskas, manager of West Pikeland Township. "The two most critical aspects of this assistance were the collaborative establishment of a methodology for prioritizing sign replacement based upon local needs and conditions, and the provision of student labor to conduct a sign inventory. The latter likely saved our community thousands of dollars."

Detective Sergeant George Smith, of the Radnor Township Police Department, provides another perspective. "It was a pleasant experience to be involved with Professors McCarthy and Park in the establishment of a collaboration between Villanova University and Radnor Township Police Department. The enthusiasm they and members of their team brought to this project was energizing and beneficial." The students helped educate the township about what the 2009 MUTCD was actually requiring for sign retroreflectivity.

Moving forward, the university and the townships are exploring additional opportunities for systematic, long-term collaboration between academia and the public sector.

"What I liked the most was going out and collecting the [signing] information ourselves, as opposed to obtaining it from a database that someone else created," says Vanvi Trieu, a graduate from Villanova University who worked on the traffic sign inventory for West Bradford and West Pikeland Townships. "By experiencing the development of an engineering practice first-hand, I was able to [see] the effort, commitment, and mindset of those who developed the things we learn in the classroom."

The experience was a positive one also for Diana Chiavetta, a senior at Villanova University currently working on a crash database analysis for southeastern Pennsylvania. "My student research project and safety assessment report allowed me to achieve a further understanding of the transportation engineering world through real-life data analysis," says Chiavetta. "Through pedestrian/bus crash pattern analysis, we were able to make countermeasure recommendations."

A student is using a retroreflectometer to conduct field measurements on this STOP sign to support data collection for the sign inventory database. *Photo: Vanvi Trieu, Villanova University.*

Vanvi Trieu, Villanova University

This student is inspecting a breakaway device mounted on a regulatory signpost to check for compliance with MUTCD requirements.

Dr. Ronald Chadderton, department chair of civil and environmental engineering at Villanova University summarizes the project: "The mutual benefit of collaborating on sorely needed transportation engineering projects has further strengthened the relationship between Villanova University and the surrounding local agencies."

Seri Park, Ph.D., P.T.P., is an assistant professor in the Department of Civil & Environmental Engineering at Villanova University. She received B.S, M.S, and Ph.D. degrees in civil engineering from Hongik University, Seoul National University, and University of California, Irvine respectively. She conducts research on traffic control and operation, highway safety, detector technology, and intelligent transportation systems. Park is a certified professional transportation planner.

Leslie Myers McCarthy, Ph.D., P.E., is an assistant professor in the Department of Civil & Environmental Engineering at Villanova University. She received her master's and Ph.D. degrees in civil engineering from University of Florida and a B.S. degree from Penn State. She conducts research on highway safety, streamlining Federal-aid project delivery, and pavement design and construction. She worked for several years at FHWA in the Office of Pavement Technology and later in the FHWA Florida Division, where she provided oversight of the State's local public agency program. McCarthy is a licensed professional engineer in New Jersey and Pennsylvania.

John McFadden, Ph.D., P.E., P.T.O.E., is technical director of the Office of Safety Research and Development at FHWA. He received his Ph.D. in civil engineering with a minor in statistics from Penn State; he also received B.S. and M.S. degrees in civil engineering from Villanova University and an M.S. in statistics from The George Washington University. McFadden is a registered professional engineer in the District of Columbia, Maryland, New Jersey, Virginia, and West Virginia. He is also a certified professional traffic operations engineer.

George Merritt is a safety and geometric design engineer for FHWA's Resource Center. In his position on the Safety and Design Technical Service Team, he serves as a technical expert for FHWA in the areas of retroreflectivity and visibility, geometric design of highways, and pedestrian safety. Merritt also has served FHWA as an area engineer in the Alabama Division and a transportation engineer in the Georgia Division. Prior to joining FHWA, he worked as a bituminous engineer for the Indiana Department of Transportation. He has a bachelor's in civil engineering from Tri-State University.

For more information, visit www1.villanova.edu/villanova/engineering/research/centers/vcase/focusAreas/sim.html or contact Leslie Myers McCarthy at 610-519-7917 or leslie.mccarthy@villanova.edu or Seri Park at 610-519-3307 or seri.park@villanova.edu.