Northern New Jersey’s Passaic and Bergen counties figure significantly in the state’s reputation for traffic snarls. Route 3 between Clifton and the Lincoln Tunnel is a confluence of interstates, state highways, and residential streets, including five major arteries: the New Jersey Turnpike, Garden State Parkway, and state highways 17, 46, and 21. It is the seventh most congested urban area in the country.

In a major reconstruction/widening of Route 3 through Clifton, New Jersey Department of Transportation (NJDOT) replaced a structurally deficient 55-year-old bridge, the Passaic River Crossing. It was a very high-profile project, but only one of several structures that comprise that particular section of highway. NJDOT replaced, upgraded, or repaired a total of six bridges as part of the Route 3 improvement. One of the six was replacing a bridge over the NJ Transit tracks, just west of the Passaic River.

About 100 miles south of Clifton, in another urban area of New Jersey, Collings Avenue (CR 630) in Camden runs smack into the junction of I-76 and I-676 before it crosses Newton Creek into South Philadelphia.

NJDOT is continuously upgrading deficient or obsolete bridges and making safety improvements throughout the state, as well as increasing capacity in its most congested areas. Workhorse structures like the bridges on Collings Avenue and Route 3 over NJ Transit—are just two of...
director’s message

Constantly moving forward

Much has happened in the months since our last issue of Transportation Today.

Soon after accepting the prestigious ASCE Pankow Award for Innovation for the RABIT™ bridge deck assessment tool we developed with FHWA, we learned it also received the ASCE New Jersey Section Project of the Year. It seems this robotic system, which provides bridge owners timely comprehensive data on bridge deck condition, is something the industry is anxious to implement.

The RABIT™ is an example of the contributions and products CAIT is turning out in its new role as a National University Transportation Center focusing on state of good repair. But we aren’t stopping there. The cover story in this issue recounts a study on skewed bridges undertaken with NJDOT by our growing Bridge Resource Program (BRP). Thanks to NJDOT, CAIT researchers had the opportunity to turn two bridges under construction into onsite labs, allowing us to monitor and measure behaviors of skewed bridges from erection to deck pour. DOTs across the country are trying to better understand and control these structures. The CAIT study will contribute valuable data and observations to the national conversation on phenomena specific to skewed bridges.

At the same time BRP was conducting the skewed bridge study, Dr. Jie Gong took advantage of the access to these structures to conduct preliminary investigations on his idea to develop a tablet app that would use LiDAR data for QC of rebar placement in deck construction. (See story on page 5.) Gong continues to find new uses for this technology: disaster recovery, identifying health risks in low-income housing, and pairing it with thermographic imaging for pipeline risk assessment. (See story on page 7.) Taking an existing technology and adapting and applying it to new, novel uses seems to be Gong’s wheelhouse and he is getting well-deserved recognition for his creativity.

Speaking of cutting-edge technologies, CAIT is expanding its activities in the rapidly accelerating area of intelligent transportation systems (ITS). New civil engineering faculty member Dr. Peter J. Jin will put his extensive knowledge to use firmly establishing a formalized ITS lab for CAIT. (See story on page 9.) Some of the first areas he will tackle include big data analytics and vehicle-to-others technologies to improve work zone safety. Thanks to Rutgers recent designation as an official FAA test site for unmanned aerial systems (UAS)—aka drones—Jin will be researching the use of unmanned vehicles and remote sensing for incident investigation and traffic diversion communications to lessen congestion. Jin also will partner with Gong to use ground- and air-deployed mobile LiDAR to efficiently create highly accurate roadway network and ITS equipment inventories.

The stories in this newsletter are just a few examples that demonstrate our commitment to maintain and improve U.S. infrastructure and that we are constantly growing and challenging ourselves as a national UTC. CAIT has several truly exciting initiatives currently underway and on the horizon that you will learn more about in the coming months. Stay tuned!

M. M. Ali Maher, Ph.D., Director

Constantly moving forward

Nearly 2,600 bridges the NJDOT Office of Bridge Engineering and Infrastructure Management is responsible for. The Collings Avenue and Route 3 bridges have several things in common. They’re both high-volume structures in extremely dense urban areas and both are the sort of “anonymous” highway spans that we drive over every day without even noticing. They also use the same primary construction materials and share a particular geometry that CAIT and other researchers are especially interested in: Severely skewed structural steel multi-girder bridges.

Doubling-down on a research opportunity

Skewed bridges present very specific engineering and construction challenges, and transportation agencies all across the country are working to better understand these notoriously “wonky” structures. Thanks to its partnership with NJDOT, CAIT’s Bridge Resource Program (BRP) had the rare opportunity to turn the Collings Avenue and Route 3 bridges into full-scale living labs and examine, instrument, measure, and monitor them top to bottom throughout construction. The hope is what we learn from these two bridges will contribute to a national search for skewed structure solutions.

Concurrently, since both the “living lab” bridges were being built with high-performance concrete (HPC) they also presented an opportunity to incorporate research on the efficacy of HPC when used under these conditions.

BRP research project manager and engineer Andrés Roda appreciated the unusual opportunity this project presented. “There are many things that are really great about the opportunity NJDOT has given us here, like being able to investigate both structural engineering aspects of two different severely skewed steel structures under construction loading, plus look at the material science aspects of HPC on real bridges while they are being built. Getting to do four studies simultaneously on two bridges throughout construction isn’t a chance that comes around too often,” said Roda.

“NJDOT has tasked CAIT’s BRP to study and develop recommended solutions to various technical issues that we have experienced during design and construction of various projects,” NJDOT Deputy State Transportation Engineer Nat Kasbekar said. “We are confident that by taking advantage of this partnership with Rutgers’ CAIT, we will be able to develop guidance to successfully address this issue.”
There were four primary components of the skewed bridges study:

- Measuring strains in the severely skewed steel girder frame as it is erected and during construction of the concrete deck. Understanding deflections during these two stages will help better understand how the frame deflects under loading.
- Measuring the strains of the rebar reinforcement in the deck during concrete pouring and curing to help understand internal forces at play during HPC curing.
- Conducting a series of tests relating to durability of HPC. Cylindrical concrete samples were collected during the deck pour and environmental conditions documented (i.e., humidity, wind, temperature, sun exposure). Following the pour, the concrete cylinders were tested in a myriad ways—for strength, shrinkage, various mineralogical and chemical characteristics, etc.—to provide insight into the HPC performance.
- Using various nondestructive evaluation (NDE) tools to gather data on the mechanical and electrical behaviors of the HPC to help gauge its durability and other properties.

**Are skewed bridges the knuckle ball of the bridge world?**

So, if skewed bridges are “complicated,” why build them? Often, it’s not possible for a bridge to span square (perpendicular) to the feature that it crosses and a skewed bridge is necessary. About 20 percent of bridges in New Jersey are skewed structures.

The supports of skewed bridges are not perpendicular to longitudinal axis of the bridge, so the way they have to be constructed—in particular, how the girders are placed and secured—creates atypical forces that lead to complex behaviors.

The CAIT BRP team started their examination of these complex behaviors by building finite element models of the bridges based on design plans and construction drawings. Looking at the models, they saw potential behaviors they wanted to take a closer look at.

This is where a living lab—a real bridge under construction—is so valuable. The team now had the ability to gather actual data and see if what was happening in the models also

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**Route 3 over NJ Transit tracks, Clifton**

**Collings Avenue over I-676, South Camden**

*Satellite images from Google maps.*
was happening in reality. With that knowledge, they could validate or further refine the models.

One thing that sets skewed bridges apart from squared structures is their tendency to behave asymmetrically. As the long, slender steel girders are being tied together with bracing—which is critical for stability—the forces at play want to make the girders “layover” or twist.

On a non-skewed bridge, the girders, bracing, and supports are all parallel or at right angles to each other. Girders are perpendicular to the supports and bracing is perpendicular to the girders, equally spaced, and exactly opposite each other along each girder in the frame. In this case, the girders are being pulled equally from both sides by each brace so they deflect equally and stay aligned.

But on a skewed bridge, the bracing either has to skew parallel with the supports or stay perpendicular to the girders. Steel fabricators prefer not to skew bracing with the supports because it makes it more difficult to connect, driving up costs and slowing down turnaround. Instead, the bracing typically stays at 90 degrees to the girder, but is staggered across the length of the bridge as the skew becomes more severe.

In this configuration, the bracing isn’t aligned exactly on opposite sides of the girder, so the girder is no longer being pulled, aka deflected, equally from both sides. This torsional effect causes the girder to twist. The same thing is happening at every bracing connection in the structure, so the issue amplifies all along the length of the bridge frame. As all these pieces are tied together the slender girders begin to layover or wobble.

When the concrete deck is poured, its additional weight compounds the wobbling, and it gets worse the further you get from the end supports. This effect is called differential deflection. Girder fabricators build in a “counter-twist” to compensate for differential deflection, but sometimes the condition persists.

Other complex behaviors may come into play on skewed bridges. Some that FHWA and other researchers across the country have documented during construction include deck thickness deviations, issues with bearings, and weight or forces unintentionally shifting. The BRP team carefully reviewed and took into consideration previous studies on these phenomena.

The concurrent concrete research BRP did entailed a series of experiments to identify various properties of the HPC. CAIT tapped the experience of two industry leaders on these experiments: SIMCO Technologies, a concrete design and testing firm, and IIS, Inc., experts in modeling complex structural behavior.

Bracing and girder arrangement for skewed versus a straight bridge: Rather than skewing bracing with the supports, the bracing on most skewed bridges remains perpendicular to the girders and is staggered across the span. Since the bracing is not pulling the girder equally from both sides, it creates a torsional effect that can cause the girder to twist.
In February 2013, CAIT capitalized on its opportunity to study the Route 3 skewed bridge by using UTC funds to support a pilot project exploring how LiDAR (light detection and ranging) technology can be used for quality control of rebar placement in bridge decks.

Position of the rebar reinforcement in a deck (the latticework of steel rods called the “cage”) changes during construction: It is in one position before concrete is poured and another after the weight of the concrete is added. After the deck is poured, inspectors need to confirm that the final position of the cage and thickness of concrete covering it are correct.

Inspecting rebar installation in newly constructed bridge decks, even before the concrete is poured, is a tedious task for field inspectors. It takes a considerable amount of time on site to measure everything and make the calculations to verify it will end up where it’s expected to according to specifications in the approved work drawings. Determining the exact location of rebar after the concrete is poured (when you can’t see it anymore) is another difficult but important step. Once the concrete hardens, the position of the reinforcement shifts yet again.

So, civil engineering professor and LiDAR expert Dr. Jie Gong set out to experiment with a process that could help make the inspection process faster and more accurate.

How do you tell exactly where the steel reinforcements are in a huge structure after they are covered in concrete?

“Ground penetrating radar (GPR)—similar to an X-ray—is often used detect rebar position and concrete cover after the construction of the bridge deck is completed,” Gong explained. “GPR is effective, but if you’re discovering quality problems in the rebar installation at that point it’s usually too late to do anything about it that won’t take a lot of time and money and it could delay opening of the bridge.”
No one wants that, so here’s what Gong and his team did:
They started with a computer model—based on approved draw-
ings and specifications—mapping where the rebar should be before
and after the concrete pour as well as once the concrete hardened.
Then, when the cage was in place on the actual bridge, they used
LiDAR to map its exact position. After the concrete was poured,
the team did another LiDAR scan of the concrete surface. Both
scans are tied to a common fixed reference point. Because LiDAR
records geospatially accurate data points in 3D, the post-pour rebar
position can be estimated by combining the pre-pour map, the sur-
face scan, and bridge deck settlement models. QA/QC checks can
be quickly conducted on the generated LiDAR maps. The accuracy
of this approach can be further calibrated by using GPR, then
extended to other construction applications in the future.
Once the technology is fully developed, the team envisions a
tablet-based LiDAR data analysis app that can be used during con-
struction to identify areas in bridge deck cages that are too high,
too low, or otherwise out of place. The app will be a useful tool to
ensure proper rebar position during construction and improve the
speed and accuracy of QA/QC inspections.

Previous page and below: Gong and his team created a 3D LiDAR
scan of the rebar before concrete was poured, then scanned the
surface after the pour. Comparing the two scans using a common
reference point can tell inspectors if a bridge deck is constructed to
specifications. Photo: ©2014 Jie Gong/Rutgers CAIT.

The team modeled and measured stresses in the concrete as it cured.
Roda explained, “Quantifying strength, modulus, durability, electric
affinity, and so forth, can help develop a more accurate performance/
deterioration curve. The curve can be used to define performance
of a bridge—or any concrete asset really. When you add this curve into an
asset management system, it makes it a more robust decision-making
tool. Contributions [like this] that can improve asset management
directly address one of the objectives specified in MAP-21, our current
transportation bill.”
The team deployed several NDE tools to measure mechanical and
electrical behavior of the concrete. They also measured various stresses
in the deck by pulling data from strain sensors that were embedded in
the concrete. All this data also was added into the models.

Results, straight from skewed bridges
“As far as the HPC, we hope to move one step closer to validating its
efficacy from both performance and cost standpoints,” Roda explained.
“What we observed on these two bridges will contribute to a meaningful
national discussion among engineers, bridge owners, fabricators, erec-
tors, academia, and researchers,” said Roda. “I’m hoping the data the
team collected will help improve modeling, construction detailing, and
construction practices and offer guidance to designers, fabricators,
and erectors on efficient ways to ‘fit up’ these structures.
“Many states are interested in this information, so this study isn’t
confined to these two bridges—it’s not even confined to New Jersey
bridges. Hopefully it can help DOTs all over the country,” Roda said.

NJDOT Project Leaders
Nat B. Kasbekar, Deputy State Transportation Engineer and
Director, Bridge Engineering and Infrastructure Management
E. David Lambert III, P.E., State Transportation Engineer,
Director, Project Management

CAIT Bridge Resource Program Project Lead
Andrés Roda, P.E., Engineering Research Project Manager

Partners on the HPC Study
Nenad Gucunski, Ph.D., Director, CAIT Infrastructure Condition
Monitoring Program (ICMP)
Franklin Moon, Ph.D., IIS, Inc.
John Prader, Ph.D., IIS, Inc.
Jacques Marchand, Ph.D., SIMCO Technologies
Eric Ouellet, SIMCO Technologies
Michel Plante, SIMCO Technologies
Patrick Powers, SIMCO Technologies
Nate Sauer, P.E., SIMCO Technologies
Old pipelines are more vulnerable just by virtue of their age, but even newer lines can be at risk after extreme weather events like Superstorm Sandy. In fact, it was the work that civil engineering faculty Dr. Jie Gong did using LiDAR to capture and archive data of Sandy’s destruction along the Jersey Shore that gave him the idea to use the same laser scanning technology and infrared imaging to assess pipeline risks.

Gong recently was awarded more than $335,000 through the USDOT Office of the Assistant Secretary for Research and Technology’s Commercial Remote Sensing and Spatial Information (CRS&SI) program, which funds research projects that effectively streamline data collection and analysis so the information can quickly be put to use outside the lab. To date, CRS&SI-funded research has focused solely on surface infrastructure. Now, CAIT is taking it underground.

**Rapid Exploitation of Commercial Remotely Sensed Imagery for Disaster Response and Recovery of Pipelines**, or the pipeline monitoring project for short, will use existing, available tools in a new way to assess and monitor pipeline condition, ultimately improving safety and enabling faster response and recovery after a disaster.

During and after hurricanes, tornados, and earthquakes, natural gas pipelines can be endangered. Increased loading from the weight of floodwaters or displaced soil and exposure caused by erosion and scour can put additional stress on pipelines, making them vulnerable to cracks, weakened welds, or punctures from heavy equipment used in emergency cleanup operations. Following a disaster, thorough pipeline safety assessments can help avoid costly damage and ensure structural integrity so the public can rely on a safe, uninterrupted flow of energy. Unfortunately, these safety checks are often hampered by two primary obstacles: a lack of sufficient data for quantifying changes in the built environment that affect pipeline conditions and a lack of data-driven risk models that identify high-risk pipe segments.

Surface-condition data obtained by remote sensing technologies can help infrastructure managers and owners identify potential issues. But molding data into meaningful risk assessment tools requires a combination of know-how and high-tech tools that aren’t always readily available.
Gong and pipeline experts from the Gas Technology Institute (GTI) are developing a threat assessment platform to analyze risks to pipeline segments in disaster scenarios. The tool will help utility operators pinpoint and respond to areas where plumes, leaks, or even explosions could occur based on changes in a pipeline’s surrounding environment.

The integrated, mobile remote sensing technology that the team is building will map pipeline locations, collect three-dimensional images of surface conditions, and couple those with detailed temperature data.

“We’re using LiDAR sensors, airborne or ground-based mobile, to scan test locations and generate high-resolution 3D models of what they ‘see,’” Gong said. “The infrared cameras detect temperature anomalies or gas leaks that could indicate threats to the integrity of the pipelines below.”

Data collected by the remote sensing tools will be fed into a point cloud and infrared imagery analysis system that semi-automates extraction of data to detect changes and anomalies in the built environment that indicate a pipeline could be compromised.

Next, the team will develop multi-layered GIS-based risk assessment software to identify high-risk pipe segments and help prioritize repairs and restoration activities.

The first layer in the software will be a GIS map, extracted from existing sources, that shows pipeline locations.

The second layer hosts an imagery analysis function that compares surface condition images or models to detect slight changes in the environment around pipelines.

The third layer reviews these changes and categorizes them under several risk factors like erosion, flooding, or building collapse.

Finally, the tool will calculate the probability of pipeline failure, damage, or disaster based on the risk factors it finds.

The platform will be tested in shore communities hit by Superstorm Sandy. In October 2012 Gong started a study using mobile LiDAR to survey and create high-resolution models of storm damage to help officials plan recovery efforts. Now, that data is being put to further use in this research. Leveraging and “repurposing” data helps squeeze even more value out of the UTC funds that supported Gong’s original Sandy project.

“We already have the surface models from our post-Sandy study in 2012. We’ll revisit those areas, collect some updated models, and upload both into our new software to test its functionality,” Gong said. “That system will compare the two models point by point to detect even the slightest changes in environment.

“It’s one thing to go out and collect data and say, ‘Here’s a colorful 3D model of what things look like,’ without deciphering what the data could mean,” Gong said. “What we’re doing with this project is not only testing the compatibility of these integrated technologies, but taking the data and preparing a threat assessment system to help decision makers direct actions where they’re most needed, optimize repair scheduling, and increase safety.”

Gong’s approach—starting with data collection and ending with real-world actionable information for decision makers—will provide a complete solution that can be readily implemented by pipeline owners and safety agencies.

More on the web:
Project updates are posted at cait.rutgers.edu/pssp/monitoring.

Read more about our partners GTI at gastecnology.org, and Rutgers School of Engineering at soe.rutgers.edu.

Below: Soil displacement and erosion caused by Superstorm Sandy left many pipelines exposed and vulnerable. Photo: ©2012 Anton Oparin/Shutterstock.com
Intelligent Transportation Systems (ITS) like traffic cams and variable message signs have become commonplace, but sophisticated new technologies are quickly emerging to meet demands for our roadways to be safer, more efficient, less congested, and less damaging to the environment.

Collaborating with NJDOT, CAIT is establishing a new ITS lab that will focus on arterial traffic management. Dr. Peter J. Jin, a civil engineering assistant professor who recently joined the Rutgers School of Engineering faculty, will lead the lab and develop research products to put our surface transportation system on the fast track.

Jin has extensive experience in probe vehicle data collection, processing, and analytics for traveler information. He was part of an R&D team that deployed a cellphone-based travel-time estimation system in Shanghai, China—a city with 20 million cellphone users. He worked for two years as a postdoc for the Center for Transportation Research at the University of Texas at Austin before coming to Rutgers.

Jin also has been active in transportation database design and data analytics. He developed or managed the development of several large-scale transportation databases through his past research, including the Road Weather Information System (RWIS) and 511 Traffic and Incident Database for FHWA and Wisconsin Department of Transportation, and a location-based social media database with Foursquare and Twitter data. In addition, he has been involved in or managed datasets of crash data, loop detector data, cellular probe data, a high-resolution vehicle trajectory database, and a closed circuit TV traffic video snapshot database.

All of Jin’s research expertise in traffic operations, big data analytics, and connected and autonomous vehicles will be put to use as he expands CAIT activities in ITS, concentrating in on four general areas.

Traffic management via Unmanned Aerial Vehicles (UAV)

UAVs—aka drones—aren’t new, but their nonmilitary use has skyrocketed in recent years. Researchers, government, ecommerce, and the supply chain/logistics industry are quickly realizing the great potential of this technology for everything from firefighting and disaster relief to delivering packages right to your door. UAVs come in all shapes and sizes; they can have a wingspan as large as a Boeing 737 or be as small as a dragonfly.

Since interest in using drones is rapidly growing in nearly every government and commercial business sector, the prospect of our skies buzzing with untested, unlimited, unregulated drones can be rather frightening. With safety as its top mission, the Federal Aviation Administration (FAA) has

General Motors’ 1940 movie *Futurama* and the sequel *Futurama II*, shown in GM’s “Highways and Horizons” exhibit at the 1964 World’s Fair, presented some outlandish predictions for the future of transportation. However, a few amazing technologies they foretold weren’t too far off the mark.
been working on the complex issue of how to let this promising technology advance and benefit the public without putting us all in danger.

To this end, after a long vetting and application process, in December 2013 the FAA named six official test sites for unmanned aircraft systems (UAS). The State of New Jersey—Rutgers specifically—was designated as an official test location as part of a consortium led by Virginia Tech, one of CAIT’s National University Transportation Center partners.

Research on using UAVs to monitor traffic dates back more than 10 years. However, recent advances in remote sensing, video analytics, and UAV technologies have significantly improved the reliability and capabilities of UAV systems, greatly expanding how they can be incorporated in surface transportation management.

Industry giants such as Amazon, UPS, and Google have devoted significant R&D resources to developing drone technologies, but primarily for supply chain applications like the “last-mile problem.” CAIT’s ITS lab will take a broader approach, studying UAV traffic management platforms and a host of connected vehicle applications that can provide aerial support to manage and respond to traffic incidents, scan infrastructure inventories, manage congestion, and provide traveler information. This is in line with the growing interests of NJDOT, especially regarding the potential for drones to assist in crash site investigation and reduce clearance time during traffic incidents.

**LiDAR-based transportation infrastructure inventories**

One of CAIT’s key technological strengths is in LiDAR-based remote sensing technologies thanks to resident faculty expert Dr. Jie Gong. Gong and his team are using LiDAR for a wide range of applications: analyzing natural disaster impacts and helping plan recovery; bridge construction quality control; detecting health hazards in low-income housing; and gas pipeline monitoring and risk assessment. (See stories on pages 5 and 7.) LiDAR also can be used to create a high-resolution geospatial inventory of transportation infrastructure. Several state DOTs, including Ohio, Illinois, and Wisconsin, have already incorporated annual LiDAR scans of their assets, using the data to manage their networks, identify and plan improvements, monitor the health of ITS assets, and prioritize maintenance.

The CAIT ITS lab will examine and develop procedures to effectively conduct LiDAR scans of New Jersey’s roadway network and ITS equipment. The resulting high-fidelity infrastructure models will be used to develop advanced arterial traffic management systems.

**Arterial traffic data collection and analytics**

Closed circuit TV video has been the primary way of monitoring traffic and road conditions to date. Obviously, installing traffic cams to cover every mile of road—and having enough personnel to keep their eyes on them all—isn’t practical. Now, advances in probe vehicle technologies make large-scale traffic monitoring possible.

Christopher Wilson, an industry expert on the topic, offers a clear explanation of what a probe vehicle is: “Probes are random vehicles moving through the transportation network providing whatever data they happen to collect to an aggregator. At a minimum, the collected data contains vehicle position and time (either explicitly or implicitly). Probes are always going about their own business and never directed, at least not with the goal of obtaining probe data at certain locations. The key differentiator between a probe-based application and other vehicle communications is that there is no relationship between probe vehicles, that is, a probe is any car that meets certain needs, such as ‘on this road less than 1 kilometer ahead,’ or ‘a car trying to park near here.’ It is never a specific vehicle …”

Probe vehicle data can be gathered in a variety of ways—via onboard devices like your GPS nav-

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**Concept of using UAVs for incident assessment and diversion communications**

A UAV can be deployed at a crash site to assess the severity of the incident and document specifics such as number and type of vehicles involved, skid marks, and vehicle positions after the crash. Then, on a programmed flight plan, the UAV can travel upstream to determine extent of the resulting backup, identifying start and end points of the congestion and how quickly it is growing and send this data to a ground operations crew. The UAV or ground crew can then communicate suggested diversion routes to approaching vehicles to help them avoid the backup.
igation system, your cellphone, or a separate sensor in the vehicle itself. Jin explains, “Probe vehicles can provide traffic and travel time information, but they can do much more than that. Real-time probe data can actively help manage traffic congestion in real time, by adjusting timing of traffic lights, managing lane usage, metering ramps, or changing posted speed limits. Analyzing aggregated historic probe data opens even more possibilities—system assessment, planning, policymaking (such as variable tolling systems), and intelligent vehicle support,” says Jin.

Major data providers such as Inrix® and HERE® can now deliver up-to-the-minute travel time data, and all state DOTs have some form of traffic information system. But Jin points out useful data sources are everywhere. “A large amount of information also can be gathered from drivers’ active participation reporting crashes and other incidents, construction delays, or sudden weather changes through Twitter, Facebook, and other social media platforms or crowdsourcing mobile apps like WAZE and I’m Stuck.

“With so many new data sources, computational engines that can effectively analyze all the historical and real-time patterns throughout the network are urgently needed if we are to take advantage of the ‘big data era’ in urban transportation system management,” Jin says.

The CAIT ITS lab will develop prototype analytic platforms that integrate existing and emerging traffic data sources and produce results that could facilitate smoother traffic operations and help identify necessary improvement projects.

Connected and autonomous vehicle technologies

Connected and autonomous vehicle (AV) technologies are prevailing trends in ITS research and development. Connected vehicle (CV) technologies use wireless communication (e.g., dedicated short-range or cellular communication) to establish connectivity vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-others (V2X), such as transit or pedestrians or even an open parking space.

Driven by Google’s recent efforts, AVs will soon be a reality for consumers. Jin and his team want to focus on evaluating CV and AV technologies for safety, effectiveness, and operability and establish a small-scale testing program for New Jersey.

Developing technologies that facilitate connectivity between vehicles, roads, and people can improve safety and mobility and lessen the negative environmental impacts of transportation. Jin is most interested in microscopic in-vehicle traffic signing and control, V2I intersection control, vehicle-based cyber security redundancy design, and V2X applications to improve safety for roadway construction workers and pedestrians.
First came a $4,250 award in January from the North/Central New Jersey section of the American Society of Highway Engineers. Then, in April he learned he was the winner of the David R. Jones Scholarship from the Association of Modified Asphalt Producers (AMAP). And at the end of May, the New Jersey Asphalt Pavement Association informed him he’d been selected for the Elaine and Robert Lang Foundation Scholarship.

Rostyslav “Rusty” Shamborovskyy, a Rutgers student working in CAIT’s Pavement Resource Program (PRP) lab, is heading into his graduate studies with some impressive academic credentials. Shamborovskyy has 4.0 GPA and his hard work has gotten him well-deserved notice from several players in the asphalt industry.

Shamborovskyy, who is starting his master’s at Rutgers School of Engineering in the fall, likes to get his hands dirty, both in and out of the CAIT PRP lab, where he has been working for the past year and a half. An avid fisherman, dirt biker, and soccer player, Shamborovskyy is studying how asphalt binders will perform 10 to 20 years into the future, and likes his work there because it is very hands on.

“When people think about civil engineering, they mostly think about construction and management,” said Shamborovskyy. He said he was drawn to studying asphalt because it is unique, requiring a different set of skills and allowing him to experiment directly with raw materials, as opposed to spending more time in front of a computer manipulating numbers.

Chris Ericson who heads up PRP’s binder operations also started as an undergraduate working in the lab. Ericson is Shamborovskyy’s supervisor and praised his work ethic and a quality he doesn’t see in every student worker: “When it comes to reliability and precision, Rusty goes the distance and makes sure testing is done accurately and on time. He also brings to the table what most people don’t: a creative mind.”

“The ultimate goal of my research is to improve asphalt technology by working to make asphalt pavement more cost effective and durable,” Shamborovskyy said, adding that in turn, that will reduce lane shutdowns for repairs, making drivers happier and reducing congestion. His other area of research interest is green technology, working with recycled asphalt pavement.

As lead technician in the PRP lab—which was reaccredited by AASHTO for the fourth time in 2013—he is working on a project extracting and reusing asphalt from post-manufacturer and post-consumer shingles. To recover the valuable reusable material from discarded roofing, Shamborovskyy uses solvents, centrifuges, and a rotary evaporator to separate the asphalt binder (black sticky stuff) from the other components of the shingles. He mixes the extracted shingles binder with virgin binder and subjects it to a variety of AMRL-certified tests, using the lab’s Dynamic Shear Rheometer, examining how susceptible they are to the effects of aging.

Asked where he sees himself career-wise in 10 or 15 years, Shamborovskyy admits that’s a tough question to answer. If he’s not in asphalt, he said he could see himself in the geotechnical industry.

Organizations from which Shamborovskyy received the awards draw members from research firms, polymer and asphalt production companies, contractors, and other related industries and government agencies. These professional groups promote technical research, education, production, and planning to advance development, production, and use of asphalt pavements.
So what actually causes potholes? Contrary to popular belief, the salt-brine deicing solution used in New Jersey and other states does not play a significant role in creating potholes. The two main pavement-destroying culprits are water and temperature.

In the winter, water from melted ice and snow seeps into cracks and tiny voids within and between the asphalt pavement layers. When the temperature drops, that water refreezes, expanding beneath the surface. The force of this expansion eventually makes the spaces and cracks larger, separating and weakening pavement layers and, in turn, diminishing the load-bearing capacity. As vehicles continue to stress these vulnerable areas, the problem worsens.

When spring arrives, rising temperatures thaw and soften the ground, reducing its ability to support the pavement structure. This loss of this critical support causes asphalt already weakened by winter’s freeze-thaw cycles to collapse, leaving the craters we’re all familiar with. In some cases, they seem to appear overnight, but in reality they’ve been lurking and growing under the surface all season; any truck or car can be the one that causes the final cave in.

Updated federal regulations allow tractor-trailers equipped with newer technologies, like steel-belted radial tires, to carry more weight. And while these long-lasting tires can expedite the movement of goods, they weigh down almost unbearably on the roadway, even at low speeds. With tire pressures of 120 psi—nearly double the average tire pressure of commercial vehicles just a few years ago—potholes are even more likely to develop and implode.

CAIT’s Pavement Resource Program (PRP) battles the damaging effects of winter, researching and developing advanced materials and pavement treatment methods that improve roadway resilience and performance in any weather. PRP program director Dr. Tom Bennert leads a number of studies on asphalt mixes and preventative maintenance treatments that can seal pavements to keep water and contaminants from in-
filtrating the spaces in and between the layers. Armed with preservation systems and practices, road owners have a fighting chance.

“We’ve created a number of pavement materials for NJDOT to help prevent weather damage. One of these is a High Performance Thin Overlay that is placed over a pavement surface. We’ve also created a protective material for bridge deck concrete, called Bridge Deck Waterproofing Surface Course, which NJDOT uses to prevent salt and water from getting into the deck and corroding steel rebars under the surface,” Bennert said. “The state adheres to a strict pavement preservation treatment schedule, so you may notice that an area of pavement that just had some major work done on it is being worked on again every few months or so.”

“Pavement preservation costs about 60 percent less than traditional rehabilitation methods if treatments are applied to roads that don’t already have significant damage,” says PRP senior pavement researcher Dr. Nick Vitillo. “A solid pavement preservation schedule will continue to seal the roadway surface, preventing water from penetrating the pavement structure. The key to treatments is applying them before the pavement surface develops significant cracking,” he advises.

Pavement preservation also is an effective safety device. According to crash analysis software, Plan4Safety, there were over 28,000 crashes in which snow and ice were a factor during 2010 and 2011. Pavement surface treatments developed by PRP can provide skid resistance and better ride quality year-round.

Vitillo says, while pavement treatments can help reduce skid-related crashes, poor road conditions are still an alarming safety issue. Another Plan4Safety analysis found there were 248 crashes in which potholes were a factor during the first four months of 2014—twice the number of similar crashes in all of 2012.

Quick fixes—like cold-patch repairs—can even out roadway surfaces to reduce vehicle damage and potential injury, but those reactive solutions often last only a little longer than they take to apply, according to Vitillo.

“Cold patch fixes are not the be-all, end-all of pothole repair,” Vitillo said. “A work crew will visit a pothole site, and inject an aggregate mix similar or identical to the surrounding pavement to fill the pothole. Traffic can drive over it almost immediately, which minimizes inconvenience to motorists, but we find that these patches can ‘pop out’ in a short time, requiring the pothole to be refilled. They are a great temporary fix, but they’re just that: temporary.”

Part of the solution, Vitillo says, is understanding and categorizing roadway conditions in real time. This supports more permanent management solutions that are essential to keep roadways pothole-free—and safe to drive.

Pavement advancements CAIT develops in partnership with NJDOT benefit municipal and county agencies as well; Bennert, Vitillo, and PRP staff offer local agencies advice about materials and show them the great economic advantages of pavement management systems (PMS). A PMS developed by Vitillo’s team under the direction of NJDOT is a data analysis and software package that categorizes pavement condition, repair schedules, and preservation and maintenance treatments. The PMS can be tailored to individual municipalities, like Howell Township and Woodbridge, New Jersey. (See story in Transportation Today January 2014 issue.)

Woodbridge engineer Scott Lee Thompson met with Vitillo and research engineer Carl Rascoe and agreed to have them inventory around 250 centerline miles of roads within limits of the state’s sixth largest city, giving each road section a condition rating.

“I came to work in Woodbridge Township as the municipal engineer in January 2004. At that time, the number one complaint from residents was the condition of our roads,” Thompson explained. He said that in 2006, under the direction of Mayor John E. McCormac, the township modified its “default” road

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**FOUR PHASES OF POTHOLE FORMATION**

1. Rain, stormwater, and melted snow penetrate the road surface and can collect in small voids and cracks in and between the pavement layers.

2. When the temperature drops before the accumulated water drains or evaporates, it freezes and expands, forcing the voids to widen, and weakening the pavement.

3. As traffic continues to pound these weakened areas, the pavement begins to break down from the inside.

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restoration mechanism from total road reconstruction to less costly milling and paving.

“We had been running the same basic road maintenance program for years and [the PMS helped us make] a huge leap in prioritizing projects. We have a lot more at our fingertips to make decisions, and we use that system to present more organized information on what we’re doing with road maintenance to residents.”

Their PMS has proven it has many advantages in addition to facilitating maintenance plans, Thompson said. It also has helped Woodbridge craft its maintenance budgets by automatically identifying roadways that need major repairs and those that need only a small investment to increase their service life.

“Using the PMS we have been able to stretch our road maintenance budget to improve many more roads in [Woodbridge],” Thompson said.

“That, in and of itself, has helped to reduce the number of potholes. In the long run, it’s going to be a huge boost for our road conditions overall.”

PRP’s research extends well beyond traditional approaches to road health. A new research study led by Bennert may have phenomenal impacts on 21st century roadways: He’s working with a team that is evaluating the effects of biomaterials in asphalt mixes and how well they could help regenerate strong and smooth asphalt surfaces.

Other studies have direct effects on rehabilitation efforts, including an evaluation of a Route 295 redesign project for NJDOT that ended up saving the state $6 million.

“Traditionally, a design would call for an 11- to 12-inch asphalt covering—and while it’s true that more asphalt layers can prevent potholes from breaking through, laying thicker pavements is not always an option for sustaining pavement health. We also found that such a thick covering would raise the roadway too high and prevent trucks from fitting under the 20 highway overpasses that this 12-mile project encompasses,” Bennert said. “We needed to find another way. Route 295 is over 35 years old, it’s the lifeblood of southern New Jersey commerce, and it desperately needed to be repaired. We thought, ‘Why not grind up the concrete layer that already exists, use that as the foundation, and then cover it with newer, more durable asphalt materials?’ And it worked.”

Even great research doesn’t realize its full value until it leaves the lab. Bennert, Vitillo, and others from the PRP team share research results and their extensive field experience in training sessions, conferences, and technical meetings like the Mid-Atlantic Quality Assurance Workshop and Rutgers Annual Asphalt Paving Conference. These events reach a large number of municipal administrators, county officials, and professional groups, such as the New Jersey League of Municipalities and National Association of County Engineers. PRP courses, like Pavement Maintenance: A Crack Treatment Seminar and Work Zone Safety for Municipal and County Public Works and Public Utilities, give professionals on the front lines weapons and strategies to battle pavement damage.

“Road work crews are the ones who really put our research to work,” Bennert said. “It’s so critical that information we disseminate to them [through CAIT’s New Jersey Local Technical Assistance Program (NJ LTAP)] explains how we arrived at our research conclusions, examples of why they work, and the importance of precision. If we don’t communicate that to the workforce, anything we find out about materials, stress effects, or successful management strategies is just ink on paper.”

Another NJ LTAP course speaks directly to pothole issues and deicing solutions. Winter Operations: Snow and Ice Control takes PRP’s research on winter pavement preservation and helps public works managers apply it directly to daily road maintenance operations.

“I think I speak for a lot of people living in the region when I say I hope we don’t have another winter like this one for a long time,” Vitillo said. “But whatever hand the weather deals us next year, we’re prepared to beat it with pavement preservation, management, research, and education.”
Hawk’s eye view of nature and the built environment

Photographer Michael Light’s perspective on infrastructure and its relationship with the natural environment is extraordinarily keen, both visually and intellectually. It’s a view very few people would see if not for his work.

“Light” is an apt name for a photographer, especially one in whose images light and space are so prominent and celebrated.

It’s no wonder Light has become one of the world’s most distinguished aerial photographers; he began flying at age 14 and taking pictures at about the same time. As a result, he has developed great passion and talent for both. “My process of both flying and photographing is a kind of perfect union,” says Light. “Each feeds the other.”

Over the last decade or so, Light has been documenting the complexity and clashes of built and natural environments. His photos offer a critique on man’s unchecked encroachment all across the landscape, yet they also somehow manage to capture the sweeping grandeur of both wide-open spaces and great swaths where humans haven’t left so much as a square foot untouched. These images express awe for engineered structures (and the triumph they represent), while simultaneously marveling at our audacity to build them.

This tension—showing the scale and power on both sides of the equation—is what many people are drawn to in his photographs.

“I’ve always been amazed at the vastness of America itself and what it does and how it does it,” Light told an interviewer from The Believer magazine. “I’m interested in the mechanics of what makes this country happen, the power structures, the natural splendor.”

There is a strong environmental message in his work, but that does not completely define it. “I’m attracted to ‘the garden,’ without a doubt, but I always try [to depict] the wolf that’s there, too. And that wolf would be us,” Light said in the Believer interview. “It’s not that we’re malevolent or evil—we’re marvelous, fantastic, tool-bearing beings [that are] capable of so much—but there are so many of us, and we don’t tend to take responsibility for what we do.”

He points out that the definitions of “nature” and “landscape” have changed, and he embraces that fact. “It was liberating to conceive of ‘nature’ as including the parking lot as well as the waterfall at Yosemite, or even the suburban backyard in the San Fernando Valley,” he says. “Once [an artist rethinks] what nature might or might not be, it can multiply outward radically. The world becomes a more interesting place to be, and one is perhaps somewhat less judgmental.”

In an article in The Atlantic Light explained his intent like this: “I don’t want to lecture or heckle. ... I want to go out there and document moments of amazement.”

Most recently his work has focused on the American West, where clear, absolute edges exist between human development—some which appears abruptly, like fantastical pop-up theme parks—and the vast “emptiness” of western prairies and deserts. It is the opposite of what we’re accustomed to along most of the Eastern Seaboard, where towns bleed into cities and it’s the undeveloped spaces that are like tiny islands strewn in the sea of urban and suburban sprawl.

To date, Light has completed 18 photo series of various western states. Much of this work is in black and white, accentuating the lunar quality of the desert landscape.

In addition to human impact on the land, themes in his work include mapping, vertigo, and aspects of geologic time.

How he executes and presents the images is fitting to the scale of the subject matter. He produces large-format books that are about three feet square and handmade with inventiveness and precision engineers would admire. He also makes oversize prints, some as large as 48 by 192 inches.

In 2007, Light received a Guggenheim Foundation Fellowship in Photography. He has exhibited extensively worldwide and his work is in the collections of the San Francisco Museum of Modern Art, the Getty Research Institute, the Los Angeles County Museum of Art, and the Smithsonian Institution in Washington, D.C.
Above and opposite page: The watersheds that feed into New York Harbor are home to more than 20 million people and its combined ports handle nearly 40 percent of all shipping trade in the North Atlantic. Light says of the area, “Its human speciation has been famously self-involved for centuries, but has recently become somewhat more thoughtful toward the larger systems that sustain it.” Photo: ©2007 Michael Light.

Right: The Lake Las Vegas housing complex in Henderson, Nevada, looks like a whimsical theme park dropped abruptly at the edge of the Lake Mead National Recreation Area. Juxtaposed with the Mojave Desert’s harsh timelessness, the development seems simultaneously tenuous and defiant. Photo: ©2011 Michael Light.
Above: The labyrinth of Los Angeles basin, including its tangle of highways, was among Light’s inspiration in the mid-2000s. “Los Angeles functions for me as a kind of holy template,” says Light. “It is postwar America.”

Right: Arch Coal’s Black Thunder mine plunges suddenly from an otherwise uninterrupted landscape, its massive scale challenging the vast Wyoming prairie surrounding it. It is the second most productive coal mine in the country. Light has described mines as “cities reversed.”

Photos: ©2007–2011 Michael Light. All images in this article were provided by and used with the permission of the artist.
Coming up CAIT

Szary recognized for leadership by CUTC

In 1998, the year CAIT was founded, Dr. Patrick Szary was a graduate student hired to work for CAIT director, Dr. Ali Maher. Today he serves as CAIT’s associate director responsible for daily operations and keeping the center’s high-quality research and training programs on target. His exemplary career is a testament to the opportunities available at CAIT.

Each year, the Council of University Transportation Centers (CUTC)—a national organization representing the USDOT University Transportation Centers—honors members who have made exceptional contributions to transportation research. On January 11, 2014, Szary received the Administrative Leadership Award at the CUTC Banquet for his work in education, workforce development, tech transfer, and research; his participation in professional organizations and public service initiatives; and mentoring students, many of whom have gone on to leadership positions themselves.

Led by Maher and Szary, CAIT has won four UTC competitions, including being named a National UTC in late 2013. Szary helps shape the center’s programs to align with USDOT strategic areas, leading to its current concentration on state of good repair, safety, and economic competitiveness. In addition to research, he ensures CAIT meets the workforce and training needs of the transportation community, offering a “cradle to grave” approach to education.

His leadership has been recognized by other regional and national professional societies, including ASCE, ITE, the Society of Research Administrators (SRA), and the National Council of University Research Administrators (NCURA). He has received kudos for his work on large complex research teams executing projects for FHWA, ITE, and ATSIP and has earned individual honors as well, such as the ASCE New Jersey Section “Young Engineer of the Year” award.

Szary has served as principal investigator, co-principal investigator, and principal researcher on more than $8 million of external grants in areas of energy, alternative fuels, infrastructure, geotechnical engineering, sensors, pavement, and weigh-in-motion.

ASCE gives bridge testing robot two prestigious awards

As we reported in the January issue of Transportation Today, the RABIT™ bridge deck inspection tool—a fully autonomous nondestructive evaluation robot—received the Charles Pankow Award for Innovation from the American Society of Civil Engineers (ASCE). On March 20, 2014, the Rutgers development team and FHWA sponsors attended the black-tie OPAL Gala in Washington, DC, where they were formally presented with the award.

On the heels of the Pankow Award, later in March CAIT learned the ASCE New Jersey Section also had selected RABIT™ for its Project of the Year. The team was presented the award at the section’s 40th Annual Awards Dinner on May 9.

More on the web: Watch the RABIT™ project video aired at the awards at bcove.me/jncugyrl.