



engineering laboratory

Newsletter • May 2011

Mission: To promote U.S. innovation and industrial competitiveness in areas of critical national priority by anticipating and meeting the measurement science and standards needs for technology-intensive manufacturing, construction, and cyber-physical systems in ways that enhance economic prosperity and improve the quality of life.

Vision: To be the source for creating critical solution-enabling measurement science, and critical technical contributions underpinning emerging standards, codes, and regulations that are used by the U.S. manufacturing, construction, and infrastructure industries to strengthen leadership in domestic and international markets.

The work of the National Institute of Standards and Technology (NIST) reorganization continues. The NIST Engineering Laboratory (EL) is busy integrating its predecessor organizations—the Building and Fire Research Laboratory and the majority of the Manufacturing Engineering Laboratory. Like the rest of NIST, EL has realigned with a mission orientation.

Building a new organization is challenging. We have identified top priority areas to address in the short-term. In building an effective EL organization, we seek to integrate diverse programs, practices, cultures, and structures. Establishing a critical national role for EL in manufacturing R&D is critical to our future direction and requires the development of a strategy for strengthening our manufacturing research programs and our stakeholder relationships/partnerships. Finally, we must ensure safe and efficient EL operations by building an enduring safety culture and reducing administrative burden where possible.

Three Strategic Goal areas have emerged from our planning efforts that will cover the breadth of EL's mission responsibilities and fit within the NIST investment priority areas and those of the Administration. Once finalized, these Strategic Goals will address measurement science and standards for:

- Smart Manufacturing, Construction, and Cyber-Physical Systems
- Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure
- Disaster-Resilient Buildings, Infrastructure, and Communities

As always, we encourage you to visit our website for more information on ongoing activities in the new Laboratory:
<http://www.nist.gov/el/>

Sincerely,

Dr. S. Shyam Sunder

Director, NIST Engineering Laboratory

New NIST Testing Device May Help to ‘Seal the Deal’ for Building Owners

Just as a chain is as strong as its weakest link, a building is as secure against the environment as its most degraded joint sealants, about 50 percent of which fail in less than 10 years after installation.

The upshot for U.S. homeowners is that moisture damage due to failed sealants is responsible for much of the \$65 billion to \$80 billion they collectively shell out for house repairs annually.

Researchers at the National Institute of Standards and Technology (NIST) are assembling a toolkit of measurement devices and scientific data that will help manufacturers of sealants systematically improve the protective performance of their products. Their latest contribution, described in the current issue of the *Review of Scientific Instruments*,* is an outdoor testing system that tracks real weather conditions—by the minute—and measures the squeezing and stretching that occur in sealants as the building moves with temperature changes.

The NIST-developed testing devices could supplant current methods, which essentially entail exposing sealants to the elements for extended periods with no movement and then visually inspecting the materials for cracks and other signs of degradation. Using materials that can be purchased at the local hardware store—such as wood, PVC pipe and toilet flanges—and combining them with arrays of load and environmen-

tal sensors, NIST research chemist Christopher White and his colleagues built a state-of-the-art testing system representative of real-world conditions.

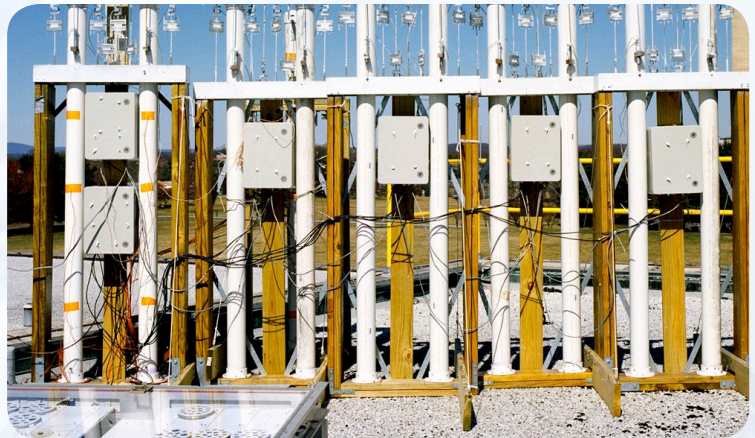
In construction, sealants are used to close gaps between building materials—usually unlike materials, such as steel and glass or wood and concrete. Different materials expand and contract differently in response to changes in temperature, relative humidity and other conditions. Because of these differences between adjacent materials, sealants are regularly stretched, compressed and, in effect, pulled in different directions.

All that motion, White says, can cause the material equivalent of fatigue, tearing and adhesion loss, allowing the water to breach the sealant defense.

“When you apply a sealant to a building joint—such as between window glass and steel in the building frame—you are trying to seal displacements that occur because the materials expand and contract at different rates,” White says.

“These new and very inexpensive testing devices,” he explains, “induce movements that are very similar to what a sealant would see in the actual application, in a building.”

Designs of the experimental testing devices have been shared with a consortium of U.S. sealant manufacturers who have already adopted this new technology. Additionally, these designs are incorporated in a new ASTM draft standard soon to be put to vote.



Mounted on the roof of a building on NIST’s Gaithersburg, Md., campus, this NIST-developed device is designed to induce temperature-caused strains on sealant specimens while monitoring loads and displacements. Affixed to a rigid base, the top segments of PVC pipe expand and contract with changes in temperature. Sensors, load cells, and specimens—sandwiched between aluminum blocks—are suspended from the top crosspiece, which moves, and are attached to the same rigid base. Credit: NIST

* C. C. White, K. T. Tan, E. P. O’Brien, D. L. Hunston, J. W. Chin and R. S. Williams. Design, fabrication, and implementation of thermally driven outdoor testing devices for building joint sealants. *Rev. Sci. Instrum.* 82, 025112 (2011); doi:10.1063/1.3543817

New Tool Debuts for Measuring Indoor Air Pollutants

A promising new approach for checking the accuracy of measurements of hazardous indoor air pollutants may soon be ready for prime time, report researchers from the National Institute of Standards and Technology (NIST) and Virginia Tech.* The measurement tool, a reference sample for volatile organic compounds (VOCs), would be a boon to testers of indoor air quality and to manufacturers of paints, rugs, cleaners, and other building products.

The researchers put their innovation—thin squares of plastic saturated with vapors of a common solvent—through the paces at four testing laboratories. The prototype test material, made at Virginia Tech, yielded measurement results more accurate than those previously achieved in more costly and time-consuming interlaboratory studies using less standardized materials.

The researchers suggest that their method might be used to produce a range of reference materials to validate measurements of VOCs emitted from building materials and products. VOCs are used in paints, adhesives, furniture, and many other indoor products. Indoor levels of some VOCs average two to five times higher than outdoors, according to the Environmental Protection Agency.

VOC emissions from building materials and products have been linked to occupant illness, reduced worker productivity, and increased requirements for ventilation/air cleaning,

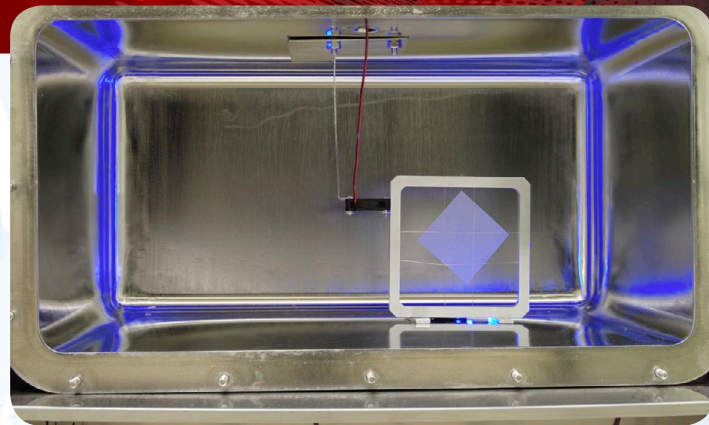
leading to increased energy consumption. As a result, low-VOC-emitting products are being used more widely in buildings to help achieve a healthy and sustainable indoor environment.

Several programs for testing VOC emissions from building products exist, and manufacturers often test their products to determine that emissions are below limits set in regulations or voluntary standards. However, results often vary significantly.

Past evaluations of test performance have been based on how much measurements reported by individual laboratories differ from the average value for the entire set of laboratories. “These kinds of inter-laboratory comparisons can take months to conduct,” explains NIST environmental engineer Cynthia Howard-Reed, lead author of the new report, “and, unfortunately, the results are relative because there is no true reference value for determining just how accurate an emission measurement really is.”

That’s the gap the researchers are trying to fill. They aim to produce VOC reference materials—standardized test samples that produce known results when analyzed. These benchmark references are commonly used in industry to check the accuracy of important measurement instruments.

In the initial trial, they prepared two



Inside the test chamber, the thin-film sample (measuring 6 centimeters on a side), which has been suffused with vapors of a common VOC, releases gas emissions at a rate similar to a real building material that can be independently determined using a fundamental model. Credit: NIST

batches of their sample material—thin films of polymethyl pentane, a plastic used in gas-permeable packaging, saturated with toluene, a common VOC found in paint and other products. A mathematical model developed by the research team is used to accurately predict rates of emission from the sample over time. The preliminary multi-laboratory tests showed that the prototype reference material is uniform in composition and sufficiently stable and that rates of VOC emissions within and between production batches are consistent.

The researchers conclude that their prototype could reduce inter-laboratory variability in results to less than 10 percent—much better than current methods.

The pilot study also identified several opportunities for improvement, which will be incorporated before an international pilot is conducted later this year. With further progress, the project will be expanded by 2013 to include more types of VOC references that will be produced in larger batches for broader distribution.

* C. Howard-Reed, Z. Liu, J. Benning, S. Cox, D. Samarov, D. Leber, A.T. Hodgson, S. Mason, D. Won and J.C. Little. Diffusion-controlled reference material for volatile organic compound emissions testing: Pilot inter-laboratory study. *Building and Environment* 46 (2011) 1504-1511.

NIST Releases Final Report on Charleston Sofa Store Fire

The National Institute of Standards and Technology (NIST) has released its final report on its study of the June 18, 2007, fire at the Sofa Super Store in Charleston, S.C., that trapped and killed nine firefighters, the highest number of firefighter deaths in a single event since 9/11. The final report is strengthened by clarifications and supplemental text based on comments provided by organizations and

enhancing building, occupant and firefighter safety nationwide. In particular, the team urged state and local communities to adopt and strictly adhere to current national model building and fire safety codes. These codes are used as models for building and fire regulations promulgated and enforced by U.S. state and local jurisdictions. Those jurisdictions have the option of incorporating some or all of the code's provisions but often adopt most provisions.

If today's model codes had been in place and rigorously followed in Charleston in 2007, the study authors said, the conditions that led to the rapid fire spread in the Sofa Super Store probably would have been prevented.

Specifically, the NIST report calls for national model building and fire codes to require sprinklers for all new commercial retail

furniture stores regardless of size, and for existing retail furniture stores with any single display area of greater than 190 square meters (2,000 square feet). Other recommendations include adopting model codes that cover high-fuel-load situations (such as a furniture store), ensuring proper fire inspections and building plan examinations, and encouraging research for a better understanding of fire situations such as venting of smoke from burning buildings and the spread of fire on furniture.

Two of the recommendations in the draft report were slightly modified to increase their effectiveness. The recommendation "that all state and local jurisdictions ensure that fire inspectors and building plan examiners are professionally qualified to a national standard" was improved by listing three nationally accepted certification examinations as examples of "how professional qualification may be demonstrated." Another recommendation has been enhanced by urging state and local jurisdictions to "provide education to firefighters on the science of fire behavior in vented and non-vented structures and how the addition of air can impact the burning characteristics of the fuel."

NIST is working with various public and private groups toward implementing changes to practices, standards, and building and fire codes based on the findings from this study.

The complete text of the final report, Volumes I and II,* may be downloaded as Adobe Acrobat (.pdf) files. For a detailed summary of the Sofa Super Store study, its findings and recommendations, and links to supporting materials such as graphics and video segments from computer simulations of the fire, go to "NIST Study on Charleston Furniture Store Fire Calls for National Safety Improvements" at www.nist.gov/el/fire_research/charleston_102810.cfm.



NIST researcher photographing the remains of the Sofa Super Store in Charleston, S.C., on June 19, 2007, the day after the fire that killed nine firefighters.

Credit: NIST Engineering Lab

individuals in response to the draft report of the study released for public comment on Oct. 28, 2010.

The revisions did not alter the study team's main finding: The major factors contributing to the rapid spread of the fire at the Sofa Super Store were large open spaces with furniture providing high-fuel loads, the inward rush of air following the breaking of windows, and a lack of sprinklers.

Based on its findings, the study team made 11 recommendations for

* Volume I: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=908200,

Volume II: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=908201.

The Buzz on BEES: New Web App Simplifies Use of NIST's Economically Green Building Products Tool

A powerful scientific tool for selecting cost-effective and environmentally preferable building products is now available as a free, Web-based application. Developed and maintained by the National Institute of Standards and Technology (NIST), BEES (Building for Environmental and Economic Sustainability) Online is based on consensus standards and designed to be practical, flexible and transparent.

The web-based version allows easier access for users and will enable new building products to be added to the database as the information becomes available.

BEES originally was developed in 1997 to bring stringent science and economics to green building product selection. "NIST wanted to reduce the environmental footprint of building products in a cost-effective way and brought science-based metrics and tools to designers and specifiers," explains Barbara Lippiatt, lead economist for the project.

BEES translates science-based, technical data on building products into decision-enabling results that can be easily understood and applied by the building community. The earlier versions of BEES, a software package made available for free download by NIST, have an estimated user base of 30,000, including designers, builders, product manufacturers and students in more than 80 countries.

BEES Online measures the environmental performance of 230 building products based on the approach called life-cycle assessment speci-



fied in the ISO (International Organization for Standardization) 14040 series of standards "to evaluate environmental performance from cradle-to-grave," says Lippiatt. The building products range from a variety of concretes to exterior wall components, roof coverings and multiple floor-covering types.

All stages in the life of a product are analyzed: raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Users can define methods to weigh the impacts, which range from global warming, smog, indoor air quality, human health and fossil fuel depletion, using predefined weights chosen by BEES stakeholders or the Environmental Protection Agency Science Advisory Board or using their own methods.

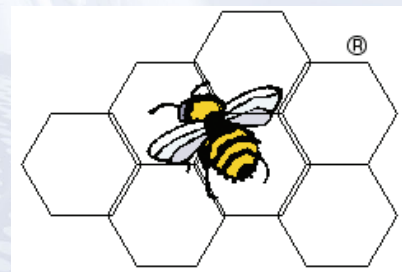
Economic performance is measured using the ASTM standard life-cycle cost method, which covers the costs of initial investment, replacement, operation, maintenance and repair, and disposal. Environmental and economic performance is combined into an overall performance measure using other ASTM standards.

Environmental and economic performance are both measured over a 50-year period. Users can choose to vary the weights for evaluating environmental and economic performance.

BEES is used to evaluate the performance of building products and can be used to help assess buildings. BEES stakeholder weights are used in the third version of the U.S. Green Building Council's LEED-certification program for sustainable commercial and residential buildings, and BEES is a valuable tool for use in certifications.

NIST's goal for building-performance research is evolving to look at whole buildings rather than components.

BEES Online is available at www.nist.gov/el/economics/BEES-Software.cfm



EL and Willow Garage Kick Off Perception Challenge

EL researchers are collaborating with Willow Garage, a relatively new robotics company, on a Perception Challenge for robotics. The competition will make its debut at the upcoming IEEE International Conference on Robotics and Automation (ICRA) in May 2011. In late 2010, researchers at Willow Garage proposed a competition that would help establish what perception problems have been “solved” and to help advance the state of perception algorithms to enable the next generation of robotics applications. The idea was favorably received by the White House Office of Science and Technology Policy, who suggested that Willow Garage partner with NIST to plan and execute the competition, given our deep experience with performance measurements for robotic technologies.

The Perception Challenge is aimed at determining the current state of maturity for robotic perception algorithms. There are hundreds, if not thousands, of perception algorithms that currently exist worldwide for identifying objects and determining their “pose” (location and orientation with respect to a coordinate frame). Yet it is difficult to ascertain for any particular project whether a current algorithm can be applied, or to predict with confidence how well it might work. In addition, efforts to develop these algorithms are being duplicated, and there is no way of readily knowing what algorithms have already solved a particular aspect of the perception problem. The Perception Challenge will help answer these questions. Robust

perception is a core enabling technology for attaining next-generation robotics. Whether the robots are used in advanced manufacturing, to assist elderly in their homes, to search for victims in collapsed buildings, to assist in construction, or most other foreseen applications, they will need to reliably identify objects in their environment and determine their location, relative to the robot. The vision for this challenge is to define desired capabilities for robotic perception that will enable competences for robots in various domains. This is a long-term effort, with the difficulties of the challenge problems increasing each year. The goal of this first competition is to show that rigid objects with lots of image cues can be reliably recognized, and that their pose in 3D can be determined using 2D and/or 3D sensors at close range (roughly personal robot arm work space, 0.5 to 1.25 meters). The objects will include component parts that you might find in a manufacturing environment, as well as some common household items. More information can be found at the ICRA Robot Challenge web page <http://www.icra2011.org/show.asp?id=40>.



This “robot’s eye view” shows how some common household objects appear through the vision system being used in the Perception Challenge. The objects are fuzzy because the cameras have limited resolution. However, the images do provide information on depth (distance of every point on an object). The checkered patterns help to define and verify objects in space.

Credit: Courtesy Willow Garage

Ground Broken for New Green Technology and Fire Safety Facilities

On March 25, 2011, the National Institute of Standards and Technology (NIST) held a groundbreaking ceremony at its Gaithersburg, Md., campus for three new facilities funded by the American Recovery and Reinvestment Act. The Net-Zero Energy Residential Test Facility, the expanded National Fire Research Laboratory, and the installation of more than 2,500 new solar energy modules to supply electricity to the NIST campus will all help to advance the state of the art in green and fire-safe building practices.

Resembling a typical suburban Maryland single-family home, the Net-Zero Energy Residential Test Facility is designed to produce as much energy as it consumes over the course of a year and will serve as a testbed for new home-scale energy technologies. The 2,700-square-foot (251-square-meter), two-story struc-

ture will use energy-saving appliances and design, as well as solar panels, to minimize the amount of energy it pulls from the grid and to generate at least an equal amount of energy. During a yearlong demonstration of the house's capabilities, appliances, lights, and kitchen and bathroom fixtures will be computer controlled to simulate a family of four living in the fully furnished home. The National Fire Research Laboratory will be expanded with a 21,400-square-foot (1,988-square-meter) laboratory space that will provide a unique capability for testing full-scale structures—up to two stories in height—as well as subassemblies and systems under realistic fire conditions.



Net-Zero Energy House
Credit: Building Science Corporation

A hydraulic loading system will help simulate the weight of an occupied building and its contents. Smoke and hot gases will be captured and treated to meet strict environmental requirements and to measure fire characteristics.

The laboratory will be managed and operated as a collaborative facility through a public-private partnership between NIST, industry, academia, and other government agencies.

The new photovoltaic system will represent a dramatic increase in NIST's commitment to implementing renewable energy sources. When complete, the new solar energy system will feed directly into the existing electrical grid, generating more than 700 MWh of electricity annually—enough to power 67 homes. The system will also provide data that will be used to develop models to better predict energy output of photovoltaic modules and arrays.



L-R: Former NIST Director Arden Bement; U.S. Department of Energy Acting Assistant Secretary and Principal Deputy Assistant Secretary, Office of Energy Efficiency and Renewable Energy Henry Kelly, U.S. Representative Chris Van Hollen; Under Secretary of Commerce for Standards and Technology Pat Gallagher; Montgomery County Council Member Nancy Floreen; and Montgomery County Council Member Phil Andrews break ground for three new facilities at the NIST Gaithersburg campus. Credit: Denease Anderson, NIST

A field toward the southern end of campus will be home to about 1,150 modules; approximately 1,000 modules will serve double-duty as canopies over a parking lot; modules installed on the roof of the campus' Administration Building will expand an existing solar system array's output threefold; and a small array on another building will power two charging stations for battery-powered maintenance vehicles.

The ceremony featured remarks by U.S. Representative Chris Van Hollen (D-Md-8); Nancy Sutley, chair of the White House Council on Environmental Quality; Henry Kelly, Acting Assistant Secretary and Principal Deputy Assistant Secretary for the Office of Energy Efficiency and Renewable Energy, U.S. Department of

Energy; former NIST Director Arden Bement, David A. Ross Distinguished Professor of Nuclear Engineering and Director of the Global Policy

Research Institute, Purdue University; and other government officials.



L-R: Division Chief, NIST Fire Research Division Anthony Hamins; U.S. Fire Administration's, National Fire Data Center Chief Brad Pabody; Director of NIST National Fire Research Laboratory Jiann Yang; NIST's EL Director S. Shyam Sunder; U.S. Fire Administration, Deputy U.S. Fire Administrator and Acting U.S. Fire Administrator Glenn Gaines; NIST Deputy Director for Building and Fire Research William Grosshandler; Research Structural Engineer John Gross; Associate Director for Fire Research, National Fire Research Laboratory Matt Bundy.

Credit: Denease Anderson, NIST

New Study Maps OutSteps to Strengthen U.S. Resilience to Earthquakes

A new National Research Council (NRC) report presents a 20-year road map that outlines steps for increasing U.S. resilience to earthquakes, including a major seismic event that could strike a heavily populated area.

Prepared by a NRC-convened committee of experts, the report, National Earthquake Resilience—Research, Implementation, and Outreach, describes 18 categories of focused activities necessary for accomplishing the strategic plan adopted by the federal government's National Earthquake Hazards Reduction Program (NEHRP). Established by Congress in 1977 with the aim of reducing the impacts of future earthquakes,

NEHRP is led by the National Institute of Standards and Technology (NIST) and includes the Federal Emergency Management Agency, National Science Foundation, and U.S. Geological Survey. NIST funded the study.

The committee defined an earthquake-resilient nation as "one in which its communities, through mitigation and predisaster preparation, develop the adaptive capacity to maintain important community functions and recover quickly when major disasters occur."

The report was mostly written prior to the March 11 earthquake in Japan, but the committee noted that the Japanese disaster is a reminder

of the devastation that can result from earthquakes, even in a country acknowledged as a leader in implementing earthquake-resilience measures. To read the NRC press release, go to: <http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=13092>

To access the full report, go to: http://www.nap.edu/catalog.php?record_id=13092

NIST EL Publishes Best Practice Guidelines for Structural Fire Resistance of Concrete and Steel Buildings

The NIST Engineering Laboratory has published NIST TN 1681, Best Practice Guidelines for Structural Fire Resistance of Concrete and Steel Buildings. The guideline is part of the NIST response to the World Trade Center (WTC) disaster of Sept. 11, 2001, and was developed in conjunction with the agency's technical building and fire safety investigation of WTC buildings 1 and 2 (the WTC towers) and 7.

The guideline report is the result of a collaborative effort initiated by NIST

that involved experts in the design and construction industry and academia. It features information on current best practices in structural fire resistance engineering in the United States and overseas, and current best knowledge in fire risk assessment, material properties at high temperatures, and thermal and structural response calculation methods. The document integrates state-of-the-art information in one source, enabling users to apply a performance-based approach to fire-resistance design as

well as the evaluation of concrete and steel structures. This guideline incorporates comments received from recently held, NIST-sponsored workshops organized by the American Society of Civil Engineers and from individually submitted comments on the draft version.

The report is available at: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=907295.

EL Hires a New Manager

Dr. Marc Levitan comes to the NIST Engineering Laboratory (EL) to lead the R&D program under the National Windstorm Impact Reduction Program (NWIRP), after an 18-year career at Louisiana State University (LSU). At LSU, he



had been an Associate Professor of Civil and Environmental Engineering and the founding Director of the LSU Hurricane

Center. Prior to joining LSU, Marc spent five years as the Managing Director of the Wind Engineering Research Field Laboratory at Texas Tech University studying wind effects on full scale buildings.

Marc will lead R&D to improve model codes, standards, design guidance, and practices for the construction and rehabilitation of buildings, structures, and lifelines. His R&D program will (1) support the development of instrumentation, data processing, archival capabilities, and standards for the instrumentation and its deployment, to measure wind, wind loading, and other properties of severe wind and structural response; (2) improve knowledge of the impact of severe wind on buildings, structures, lifelines, and communities; (3) develop cost-effective windstorm impact reduction tools, methods, and technologies; (4) work in conjunction with private-sector organizations and other appropriate Federal agencies to support the development of wind standards, model codes, and better building practices. Marc will coordinate with EL's Disas-

ter and Failure Studies Program and with the other NWIRP agencies and stakeholders to respond to disaster and failure events following severe windstorm events. He will also support the development of tools and methods for the collection of data on the loss of and damage to structures, and data on surviving structures after severe such events.

Marc holds a bachelor's degree (1985) in architecture and in civil engineering as well as a master's degree (1988) and doctoral degree (1993) in civil engineering, all from Texas Tech.

Staff Awards

Engineering Laboratory Awards

Distinguished Associate Award

- Yihai Bao
- Donghyun Rim
- George Cajaty Barbosa Braga
- Walter Rossiter
- Tom Kramer
- Yuyin Song

2010 Support Award

- Roy McLane
- Alma Duke

2010 Safety Award

- Richard Harris
- Eric Byrd
- Charles Giauque
- Michael Kennedy
- Steve Nabinger
- Randy Shields

2009 Communication Award

- William Mell
- Alexander Maranghides
- Randall McDermott
- Samuel L. Manzello

2009 Communicator Award

- Dale Bentz

DOC/NIST Awards and Recognition

Gold Medal Award

- Joannie W. Chin (group award)

Silver Medal Award

- Jack Hayes

Bronze Medal Award

- Peter O. Denno
- Stephen B. Balakirsky
- Joseph A. Falco
- Frederick M. Proctor

Edward Bennett Rosa Award

- Kang B. Lee

Colleagues' Choice Award

- John W. Hettenhouser

NIST Director's Award for Excellence in Administration

- Kristy Thompson

Recent Publications

- Information Model for Disassembly for Reuse, Recycling, and Remanufacturing NISTIR 7772 04/13/2011 (Publication 907616)
- Communicating the Emergency: Preliminary Findings on the Elements of an Effective Public Warning Message NIST TN 1689 02/28/2011 (Publication 907983)
- Internal Curing: A 2010 State-of-the-Art Review NISTIR 7765 02/09/2011 (Publication 907729)

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For more information about EL, please visit our website at www.nist.gov/el/

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