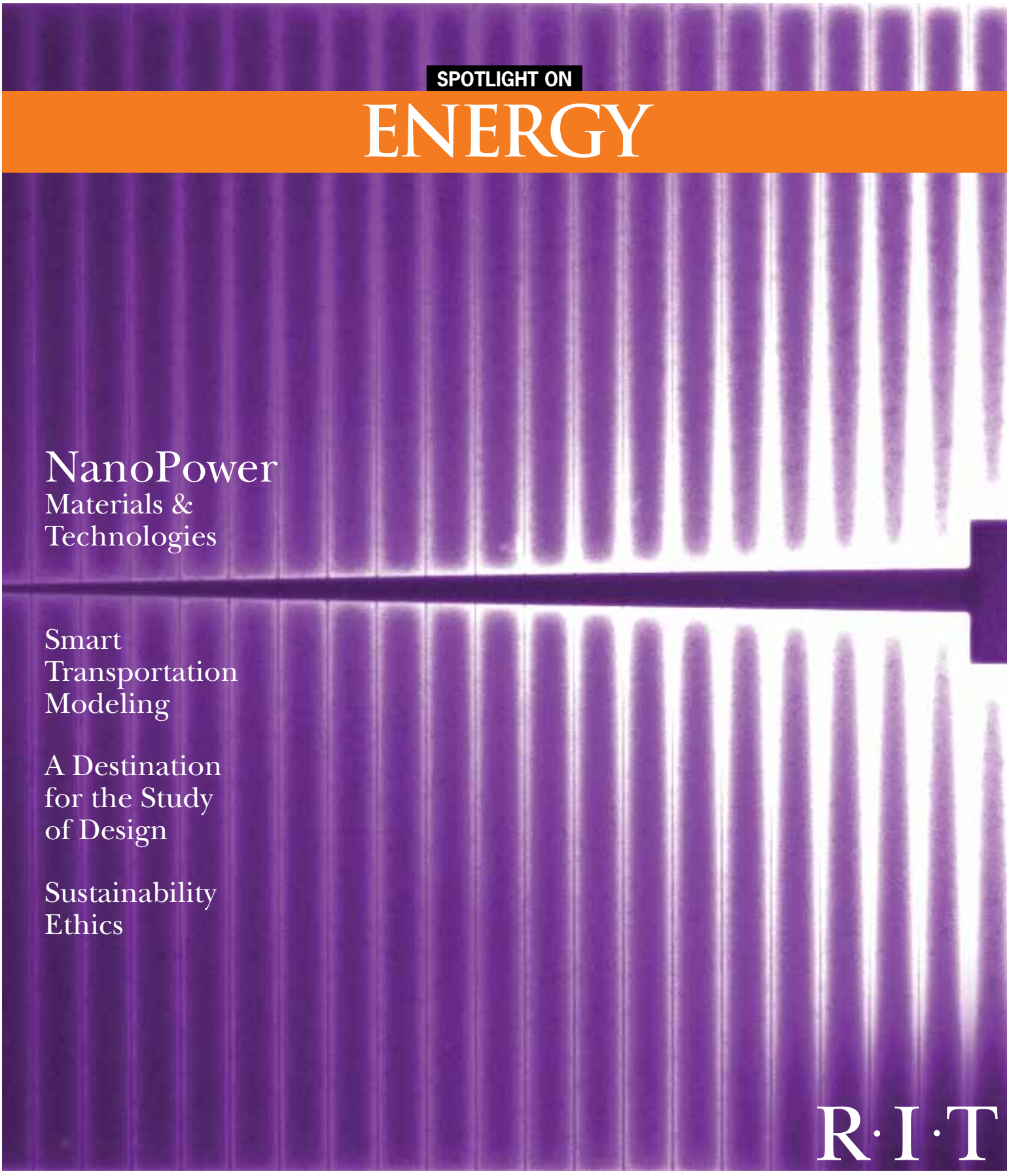
RESEARCH at RIT

The Rochester Institute of Technology Research Report

Fall/Winter 2010



SPOTLIGHT ON

ENERGY

NanoPower
Materials &
Technologies

Smart
Transportation
Modeling

A Destination
for the Study
of Design

Sustainability
Ethics

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Experience the Energy

RIT researchers, faculty and students alike, are helping to address some of the most dire energy challenges facing the world.

Every day our lives are influenced by energy—whether it is the gas powering our car, the electricity keeping the lights on, or the coffee jump starting our morning. It's all about energy. As we go about our day to day lives, it can be easy to forget about the realities that threaten these everyday conveniences or the impact they have on the world around us—from our dependency on foreign oil and the impact emissions have on the environment to the depletion of non-renewable resources to the sustainability and management of agriculture.

In this issue you will learn about how RIT researchers, faculty and students alike, are helping to address some of the most dire energy challenges facing the world.

In our opening story we highlight the NanoPower Research Laboratories, which were established in 2001 by Dr. Ryne Raffaelle. Since that time, the lab has made significant progress in the development of new materials and devices utilizing nano-materials and nanotechnology for energy conversion, energy storage, and power systems development. Their research has shown strong potential for the realization of alternative energy sources. Recently, the U.S. Department of Energy named Raffaelle director of the National Center for Photovoltaics. We are pleased that the research team that he established remains strong and will continue to expand the application of nanotechnology to address our energy challenges.

A cross-campus collaboration at the Laboratory for Environmental Computing and Decision Making is developing computer-based models that aim to better manage freight transport, reduce fuel consumption, and assess the impact of laws designed to reduce vehicle emissions.

The solutions to these energy and sustainability questions are often challenged by competing viewpoints—be it from engineers, environmentalists, or economists. Professors at the Golisano Institute for Sustainability and the College of Liberal Arts address the inherent competition between now and later through their work on sustainability ethics. They are developing new educational methods that help to expose these issues and provide students with an experience that will help to guide their decision-making skills.

This issue also explores the remarkable contributions of R. Roger Remington from RIT's nationally recognized School of Design, where he and other outstanding designers have made RIT an international destination for the study of graphic design.

Please enjoy this issue and *experience the energy at RIT*.

Best Regards,

Donald Boyd, Ph.D.
Vice President for Research

Inside this Issue

On the Cover

A crystalline III-V solar cell is characterized by electroluminescence. The cell is forward biased and acts as a light emitting diode. Images of light emission from the solar cell allow researchers at the NanoPower Research Laboratories to visualize material defects and fabrication errors. Results from this analysis can be used to optimize the manufacturing process to produce better cells.

NanoPower Research Labs: Founded in 2001, NPRL is internationally recognized for its capabilities in synthesis and characterization of nanomaterials and the development of advanced photovoltaics and battery technologies. The laboratories span over 7,000 square feet and employ 15 faculty and staff members, along with 23 students.

NanoPower Materials & Technologies

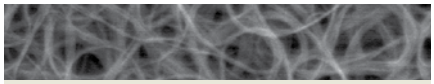
by Kara Teske

As the world faces unprecedented energy challenges, researchers at RIT's NanoPower Research Laboratories are developing renewable energy technologies that offer sustainable solutions to the world's energy needs.

Nanotechnologies to Advance Renewable Energy

Every hour the sun radiates more energy onto the Earth's surface than is consumed globally in one year. To harness the power of solar energy, improvements in the efficiency of photovoltaics and electrical storage are required to reduce variability and intermittency of solar power. RIT's NanoPower Research Laboratories (NPRL) are making significant advances in the development of new materials and devices utilizing nanomaterials and nanotechnology for energy conversion, energy storage, and power systems development.

Dr. Ryne Raffaelle founded the NPRL in 2001 and has developed the laboratory into a center that spans over 7,000 square feet across the IT Collaboratory, College of Science, and Center for Integrated Manufacturing Studies buildings with 15 faculty and staff members, along with 23 students. The labs are equipped with a wet chemistry synthesis facility; a photovoltaic characterization facility; a thermal, spectroscopic, and microscopic characterization facility; battery testing lab; and a laser lab. The NPRL is internationally recognized for its capabilities in synthesis and characterization of nanomaterials. Recently,



Know Your Nano

III-V – refers to materials found in columns three and five of the periodic table.

GaAs – the compound of the two elements gallium and arsenide.
InAs – the compound of the two elements indium and arsenide.
GaSb – the compound of the two elements gallium and antimonide.

Carbon Nanotubes – an allotrope of carbon found to have extraordinary strength and unique electrical properties. You can picture a single-walled carbon nanotube as a rolled up graphene sheet–or nanoscale "chicken wire" made of carbon atoms and their bonds–that form a seamless cylinder with fullerene caps. The chirality or twist of the SWCNT determines if it will be metallic or semiconducting in nature.

Photovoltaics (solar cells) – a device that converts light or solar energy directly into electricity.

Quantum Dots – a semiconductor where the electron is confined in all three dimensions and allows the absorption of the material to be controlled and tunes the solar cell based on the desired application.

Lithium Ion Batteries – commonly used in consumer electronics, lithium ion batteries are a type of rechargeable battery in which a lithium ion moves between the anode and cathode.

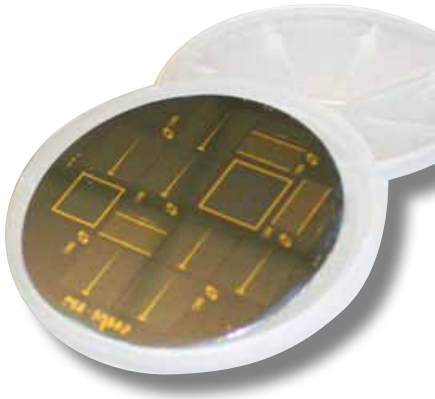
the U.S. Department of Energy named Raffaelle director of the National Center for Photovoltaics.

"NPRL's expertise is unique in that not only do they focus on fundamental material research, but also advanced device research. From developing advanced photovoltaics to enhancing battery technology that better support these renewable energies and synthesizing new materials that will enable the advancement of these new technologies—this is the breadth of the expertise of the NPRL," says Raffaelle.

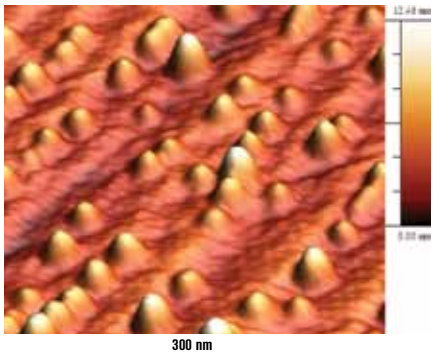
Improving Photovoltaic Efficiency

With the national emphasis toward renewable energy, chances are you have a solar-powered device in your home—whether it is a light, calculator, or solar panels to help power your home. However, in order to support large-scale energy demands with solar power, significant advancements in photovoltaic (or solar cell) technologies are required. The first generation of solar cells found in most devices available today uses silicon. While silicon is highly abundant and these types of solar cells can be easily manufactured, the best power conversion efficiency is only 24%. The NPRL is focused on developing semiconducting photovoltaics using both III-V materials and polymers, with the bottom line goal to increase efficiency while decreasing the manufacturing costs associated with cell fabrication. Increased efficiency and reduced cost lead directly to cheaper electricity (cost per watt).

III-V materials are naturally better suited for photovoltaic applications because they are better absorbers of light than silicon. Another advantage is the versatility and availability of different III-V materials, leading to the ability to stack multiple absorber layers. This approach provides a better match between the III-V absorbers and the solar spectrum, reducing the amount of sunlight lost to heat,



Crystalline III-V Solar Cell: Researchers at the NPRL are using III-V materials to increase efficiency in state-of-the-art photovoltaics. III-V materials are naturally better absorbers of light. The versatility of III-V materials also make them attractive for photovoltaic applications.



Quantum Dots: The image above is an atomic force micrograph of the surface of a GaAs substrate with InAs quantum dots grown on top. Each small island seen in the image represents one InAs quantum dots. The average size of these quantum dots is approximately 6 nm in height by 30 nm wide at the base. The dimensions of the quantum dots are on the order of an electrons wavelength, allowing the electrical, optical, mechanical, and even thermal properties to be controlled by changing the quantum dot size.

Class A Close Match Solar Simulator: Dr. Seth Hubbard, assistant professor of physics and microsystems engineering, analyzes the results of a characterization test with Chelsea Plourde, research associate, and Stephen Polly, microsystems doctoral student. The research team is using the Class A Close Match Solar Simulator to test how solar cells will perform under both terrestrial and extraterrestrial conditions.

which in turn increases the efficiency of the cell. Standard commercial silicon solar cells available today are approximately 15-20% efficient—that is to say, only 15-20% of the sunlight is actually converted into electricity and the other 80-85% is lost to heat.

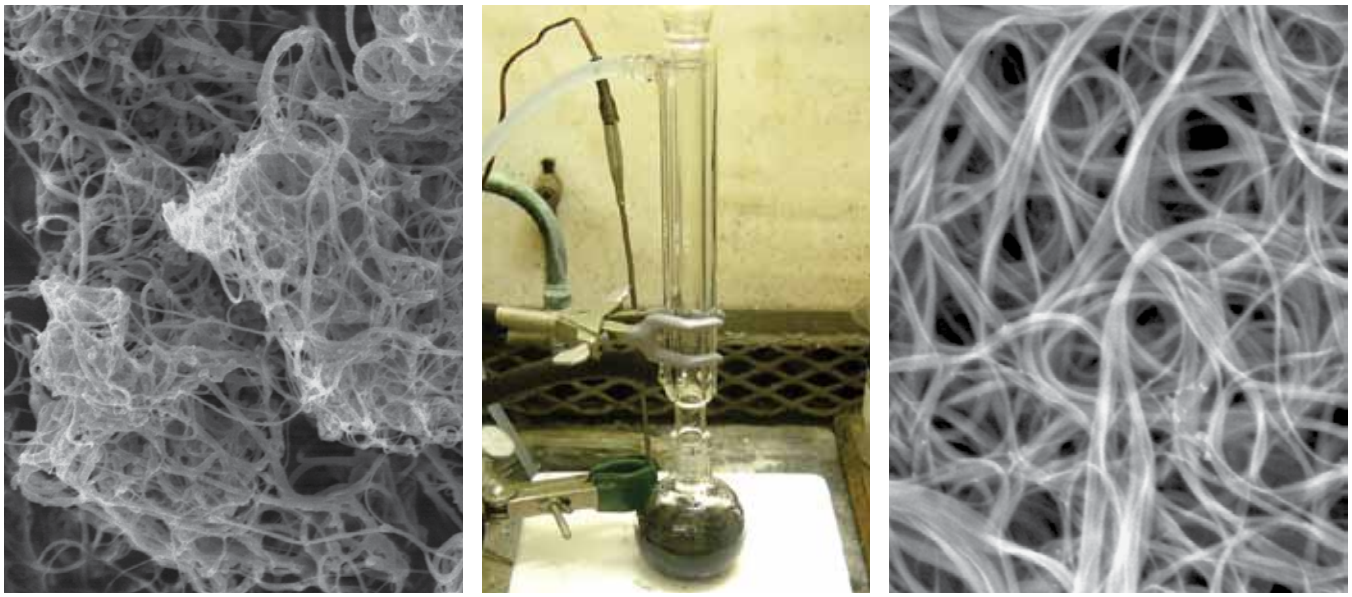
"With III-V materials we will be able to harness different parts of the solar spectrum, increasing the overall efficiency of the solar cell," says Dr. Seth Hubbard, assistant professor of physics and microsystems engineering.

Additionally, the incorporation of nanostructures into III-V materials seeks to develop new paradigms for photovoltaic conversion. Nanostructured photovoltaics make use of electrical and optical properties of nanomaterials that can be controlled by changing the particle size at the atomic level. The main challenge of using nanostructures with III-V photovoltaic cells is the actual incorporation of the nanostructures into the solar cells without disrupting the fundamental structure of the cell.

Many questions need to be answered—What's the best way to insert the nanostructures? What size is needed? What is the best location? What type of cell designs are necessary? While research is underway to address these long-term considerations to III-V nanostructured photovoltaics, the lab has shown short-term progress through the use of quantum dots. Quantum dots can be used to tune a solar cell and allow the absorption of the cell to be controlled. The NPRL is one of the few research groups in the world that have been able to show enhanced efficiency in solar cells through the use of quantum dots. By incorporating InAs and GaSb quantum dots into a standard GaAs solar cell, the research team has been able to show improvements in the current density.

"Our research predicts with the integration of quantum dots efficiency could reach levels as high as 47%," says Hubbard.

Another approach to increase efficiency and reduce cost per watt is through the use of high concentration photovoltaic solar cells. Instead of covering a large area—like the roof of a home—with a traditional flat-plate system, sunlight is focused down using parabolic mirrors or lenses. Similar to what happens when you put a magnifying glass over a piece of paper in the sun and the paper burns, the sunlight is intensified from 500 or 1,000 watts per meter^2 at normal intensity to tens or hundreds of thousands watts per meter^2. However, in concentrator photovoltaics, this intense light is converted to electricity. This approach allows engineers to replace III-V materials with less expensive materials, thus making the system more cost effective. In addition, while an increase in temperature reduces efficiency, the added efficiency from concentration far outweighs the decreased efficiency caused from the heat. Researchers at the NPRL are focused on improving both the efficiency and reliability of these concen-



Single-walled Carbon Nanotube Purification: The image on the left shows raw SWCNTs, a naturally occurring allotrope of carbon. Through a purification process using acid reflux (shown center) and thermal oxidation, the NPRL is working to improve and verify the quality and consistency of the material. Research shows the purified material (right) provides greater efficiency in technologies like lithium ion batteries.

trator cells and the integration of these cells into system-level designs.

A cornerstone of the NPRL is the lab's unmatched solar cell testing capabilities. The laboratory follows a strict standard for solar simulation and specification so results can be compared universally. A standard is especially critical when qualifying devices for space-based applications. The NPRL has built a Class A Close Match Solar Simulator that allows researchers to test how cells will perform under both terrestrial conditions at different locations (by adjusting the spectrum based on the location) and also extraterrestrial conditions, similar to the conditions that solar panels on our communications satellites encounter.

The fundamental theory of nanostrucuted III-V photovoltaics suggests a significant increase in solar cell efficiency. "However, many questions remain to be answered and a lot of it comes down to the materials," says Hubbard. "We are looking wherever we can to find a way to break the current limits of photovoltaics using nanotechnology." Generating electricity is half the challenge; then it becomes a question of creating storage solutions that can support mass power generation.

The Power in the Black Powder

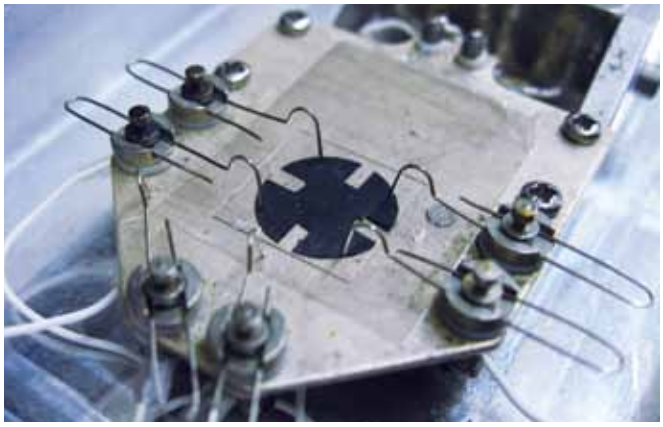
Carbon nanotubes have shown tremendous potential for power generation and storage devices due to their remarkable properties. Said to be one of the most conductive and strongest materials yet discovered, the synthesis, characterization, and application of carbon nanotubes have been one of the core research focuses of the NPRL since its founding.

"Like diamonds, single-walled carbon nanotubes (SWCNTs) are another allotrope of carbon. In the laboratory we are modifying the conditions to increase the quantity of SWCNTs we produce, along with the purity of the material," says Dr. Brian Landi, assistant professor of chemical engineering.

One of the main challenges of SWCNTs is the ability to verify quality and consistency of the material. Recent characterization studies conducted at NPRL have provided a better understanding of the fundamental properties, helping researchers to better control material properties.

Using optical spectroscopy, the lab has developed a patent-pending technique that measures the purity of the material. The material is dispersed in a solvent and using spectroscopy, absorption peaks are measured to determine the purity of the sample. Using a simple calibration curve from the peak height intensity, NPRL is able to standardize the purity of its SWCNT materials and assess the purity of the materials provided by commercial vendors.

Extensive work in the lab is being done to use carbon nanotube (CNT) wires to replace ordinary copper wiring in spacecraft applications, such as communication systems. CNT wires are much stronger, more flexible and durable, and lighter, which provides significant weight savings advantages for space-based applications.



Testing Conductivity: Characterization tests are conducted to determine the conductivity of the carbon nanotube paper. Carbon nanotube papers and wires have shown to be much stronger, more flexible and durable, and lighter than ordinary copper wiring.

Improving Lithium Ion Batteries: Dr. Brian Landi, assistant professor of chemical engineering, is working with Matthew Ganter, sustainability doctoral student, and Roberta DiLeo, microsystems engineering doctoral student, to enhance lithium ion batteries by replacing the graphite materials used as the anode with carbon nanotube papers.

As the accessibility of copper diminishes, CNT wires have the ability to replace traditional wiring in a wide variety of everyday applications. Currently, conductivity of CNT wires is about equal to copper. The lab is working to improve conductivity by treating the CNT wires through exposure to acids, bases, and ionic solutions.

It is clear carbon nanotubes can provide a powerful solution for renewable energy technologies; however, continued characterization studies are required to be able to develop the material with the consistency and dependability carbon nanotube-based devices demand.

An Energy Storage Solution

Because of their unique electrochemical and mechanical properties, one of the devices carbon nanotubes are ideal for are lithium ion batteries. Lithium ion batteries, like the one found in your cellphone, provide superior energy density over any other battery available to date. By nature, lithium is the lightest metal and therefore batteries using lithium have the highest specific capacity. "This is the very reason consumer electronics have been able to make significant advances in the last decade," explains Landi.

With the demand for better energy storage, the NPRL is working to enhance the lithium ion battery by replacing the graphite materials used as the anode with carbon nanotube papers. Carbon nanotubes offer many distinct advantages over the graphite material. Carbon nanotubes are not only conductive electrically but absorb lithium and because it is lighter in nature, the capacity is immediately increased threefold. Their strength and flexibility also make it attractive to prevent cracking during operation or in vibration environments.

"We are seeing that higher purity materials have higher capacity. In addition, when we change the electrolytes in the battery, it affects how it interacts with the nanotubes and that also changes the capacity," says Landi.

These results demonstrate not only the importance of understanding how the material properties affect the device performance, but also how all the constraints of the device—assembly, electrolytes, etc.—affect the material. For this reason, NPRL is focused on not only being an expert on materials, but also the devices and the testing of these devices.

A Research and Development Center for Industry and Government

The laboratory provides a research and development backbone for industrial collaborators, including BP Solar, Ohmcraft, Lockheed Martin, Northrop Grumman, Boeing Spectrolab, Greatbatch, ITT, Emcore Photovoltaics, Reflexsite, and Alpha V (an RIT startup company), along with governmental agencies such as NASA and the Air Force Research Laboratory. The support of local, state, and federal governments has also made the laboratory's research efforts possible, helping to advance renewable energy technologies that are critical to addressing the global energy crisis.

"Renewable energy technologies, like the ones under development at NPRL, present great promise to addressing the global energy crisis. However, legislation is key. For people like us to want to have renewable energy sources powering our homes, legislation has to pave the way," says Raffaelle. "The support of our congressmen Chris Lee and Steve Israel, as well as former congressmen Jim Walsh, Randy Kuhl, and Tom Reynolds, has been integral to the success of our lab. Efforts like this are what will help to make our research become reality for you and me."

On the Web

More information about this work and other related research is available online.
www.sustainability.rit.edu/nanopower

Reducing Energy Use in Supercomputers


Lizhe Wang

High-performance supercomputers provide significantly increased memory and computing power, while allowing for expanded applications that can advance research and development in areas such as astronomy, medicine, and engineering. However, these systems use a tremendous amount of energy and produce a lot of heat, which requires the use of additional high-power cooling systems. As the benefits these supercomputers provide become more essential, methods are being developed to both reduce energy use and operate these systems more efficiently.

Currently a research team at RIT, led by research scientist Dr. Lizhe Wang, has several efforts underway designed to reduce energy use in supercomputers and create more efficient procedures for the operation of these systems.

"Supercomputers represent the next step in advancing computing application and development," notes Wang, assistant director of the Service Oriented Cyberinfrastructure Lab in the B. Thomas Golisano College of Computing and Information Sciences. "However, the energy use associated with these systems, and the impact this has on the environment and system cost, is currently an impediment to expanding supercomputer use."

"At RIT, we are attempting to develop processes that can assist in reducing run times, better schedule jobs, and reduce the need for cooling systems that add to energy use," adds Wang.

For example, the team is building a Green Web 2.0 portal for use by supercomputing centers. The portal will allow researchers from all over the world to access grid resources in the most energy-efficient mode possible. The portal will also allow computer centers to better schedule use of its supercomputers and more efficiently operate the entire system.

"One of the main problems with supercomputing centers is the large number of users and difficulty in efficiently and productively scheduling the literally thousands of jobs the system is required to run," Wang says. "By creating a virtual portal and manager, more people can use the system more efficiently."

The work conducted is partially funded through the National Science Foundation.

Enhancing Energy Efficiency for Tera Grid: RIT computer scientists are developing a Web 2.0 portal that will be used by the supercomputing consortium Tera Grid to better schedule and manage jobs being run on the system. It is designed to reduce run times and enhance energy efficiency in supercomputing systems.

Advancing Quantum Optics


Stefan Preble

Many experts believe that the use of quantum optics, where individual particles of light are used to represent information, may hold the key for creating the next generation of communication and computing systems. Unlike conventional bits used in today's computers, quantum bits (qubits) have the unique property that allows them to have multiple values at the same time. This greatly enhances the functionality of quantum computing as compared to traditional microelectronic technology.

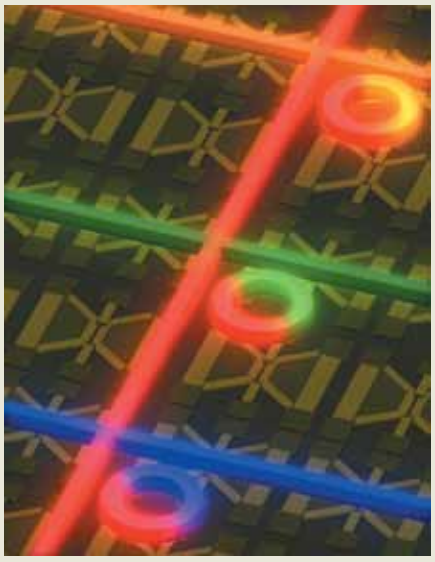
A team of engineers from RIT's Kate Gleason College of Engineering is attempting to enhance quantum optic technology by building the first active quantum optic devices on traditional silicon chips. The project, funded by the National Science Foundation, has the potential to greatly increase the functionality of quantum communication and information processing systems.

"Quantum optics deals with the manipulation of light at the particle level and the use of these particles, known as photons, to create capabilities that are not possible using the electrons in computer chips today," explains Dr. Stefan Preble, assistant professor of microsystems engineering at RIT and leader of the research team.

Preble notes that, historically, quantum optic devices have been implemented using large-scale and difficult to integrate bulk components, such as lenses and mirrors. However, to become commercially viable, quantum technologies will need to be miniaturized in order to dramatically improve reliability.

A functionality that will be required in future quantum information chips is a single photon wavelength converter. Typically hundreds of millions of light particles, using a tremendous amount of energy, are needed to change the wavelength of just a single photon. The research team will utilize a new method, developed by Preble, that can change a single photon's wavelength through the use of a low-power electric signal.

"Low-power wavelength conversion allows us to control the flow of photons on a chip," adds Preble. "This will enable high-performance quantum computers that will revolutionize how we process information in the future."



Low-power Wavelength Conversion: The flow of photons is able to be controlled using low-powered wavelength converters. This artistic rendering shows three low-powered wavelength converters on a silicon chip changing the color of light from red to blue and from green to orange (from bottom to top).

Multimodal Modeling to Enhance Decision Making: RIT's Lab for Environmental Computing and Decision Making is modeling the environmental, cost, and logistical impacts of freight movement to assist planners in choosing the optimal routes and modes of transit for their operations. The work is also helping policy makers make better decisions about what types of transportation, regulations, and technology investments will best meet the policy goals. The multidisciplinary effort includes student and faculty members from a wide variety of RIT departments, as well as affiliate partners from the University of Delaware, the University of Michigan, the National Science Foundation, the U.S. Department of Transportation Maritime Administration, and the Great Lakes Maritime Institute.

Smart Transportation Modeling

by William Dube

The lack of quantifiable data to assess transportation policies is a central impediment to improving transportation networks. RIT is applying computer-based models that aim to better inform public and private decision makers with quantifiable data.

Providing Decision Makers with Better Data

"Policy makers often make decisions based on incomplete information, leading to potentially disastrous unintended consequences," says Dr. James Winebrake, professor and chair of the department of science, technology, and society/public policy. "This is particularly true in the energy and environmental fields."

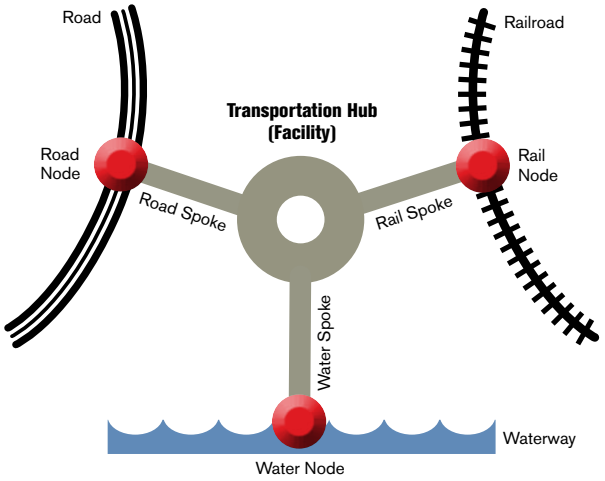
For example, federal mandates are currently in place to increase production of ethanol as an alternative to conventional fuels. However, such mandates may induce other effects, such as poor land use practices or increases in food prices.

"The unintended consequences of environmental decision making need to be studied through the acquisition of data and application of energy, environmental, and economic models. Understanding these impacts will help decision makers make better decisions," adds Dr. Karl Korfmacher, associate professor of biological sciences.

To address this dilemma and develop a more synergistic approach to environmental policy making, Winebrake, Korfmacher, and Dr. Scott Hawker, assistant professor of software engineering, are leading a multidisciplinary, multi-university effort aimed at incorporating novel computing and modeling technologies into the environmental decision making process. The Lab for Environmental Computing and Decision Making (LECDM), seeks to develop better data on the cost and benefits of different environmental policies and technologies, while also providing insights on which policies, when used in combination, provide enhanced benefit.

The lab is currently working with the National Science Foundation, the Great Lakes Maritime Research Institute, the U.S. Department of Transportation, and the state of California, among others, to develop new transportation models that can assist policy makers in better managing freight transport and better assessing the impact of new laws designed to reduce vehicle emissions. The lab also utilizes modeling tools to improve a host of additional policy making functions including analysis of consumer decision making and emergency preparedness.

"New modeling techniques have the potential to greatly improve public policy analysis," notes Hawker. "These models can ultimately be used by individual municipalities, federal agencies, and global non-governmental organizations to better inform public decisions related to environmental quality, alternative energy development, and sustainable transportation design."

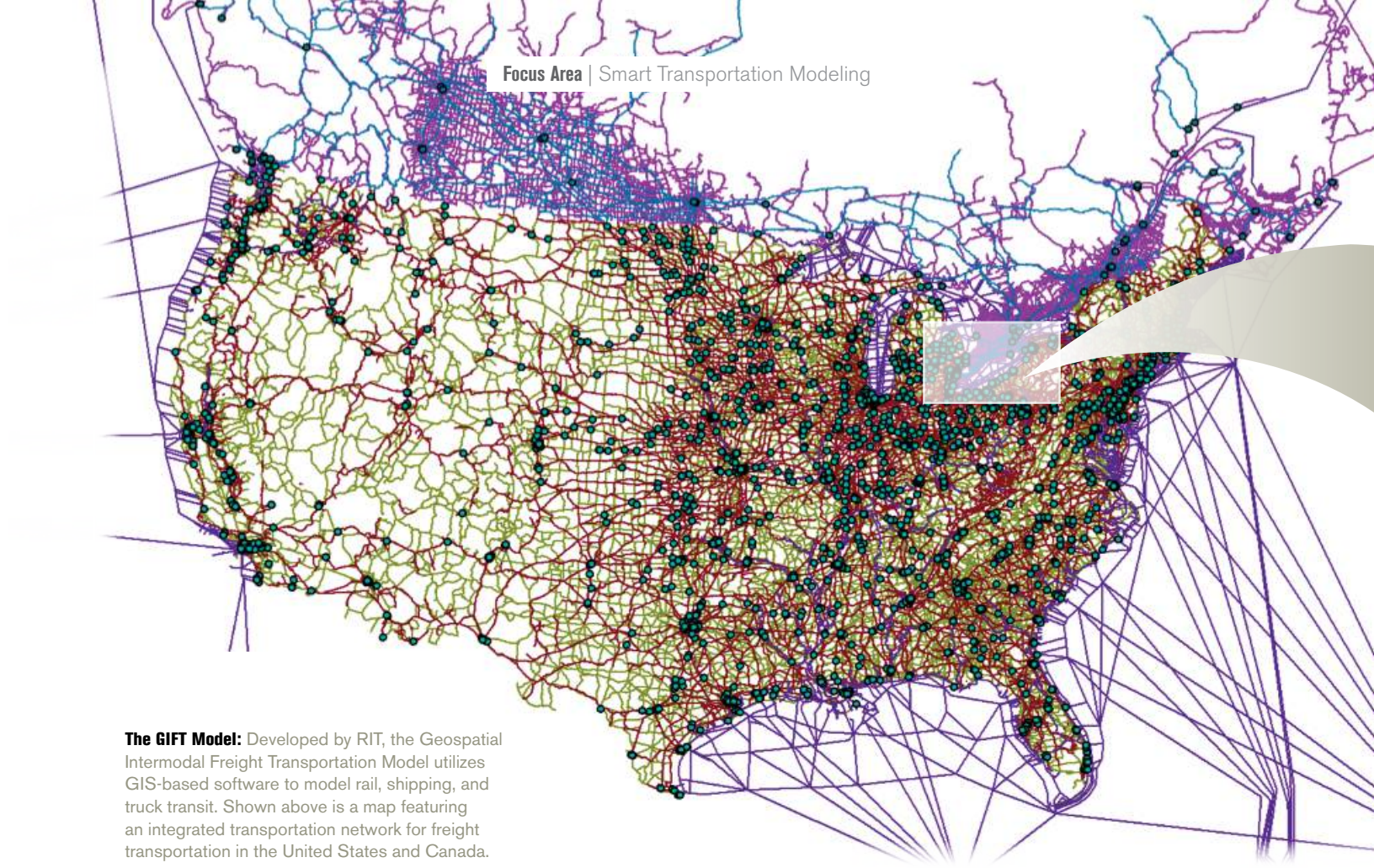


Connecting Multiple Modes: RIT's transportation modeling research seeks to better assess the use of multiple modes of transit, including rail, ship, and truck to move goods. Multi-modal transit has been shown to reduce the cost and environmental impact of freight transport.

Better Management of Goods Movement

A major issue in designing more sustainable transportation systems deals with the movement of commercial goods. The transportation of freight in the United States is conducted mainly over land by heavy-duty trucks, which consume large amounts of imported petroleum, release significant amounts of greenhouse gas emissions, and cause considerable congestion on America's highways. For example, the transport of one truckload of freight from Cleveland to Toronto releases an estimated 340 kilograms of carbon dioxide and 2210 grams of nitrogen oxides. The use of alternative transit methods, such as rail and ship, can reduce these environmental impacts, but travel times are often longer.

"Intermodal transit, where multiple methods of transport are used to move goods, is now seen by most planners as an excellent alternative because it reduces the environmental impacts of all modes, while using the fastest routes to reduce time and cost," says Dr. Sandra Rothenberg, associate professor of management and an affiliate researcher of LECDM.



The GIFT Model: Developed by RIT, the Geospatial Intermodal Freight Transportation Model utilizes GIS-based software to model rail, shipping, and truck transit. Shown above is a map featuring an integrated transportation network for freight transportation in the United States and Canada.

To better assess the uses and impacts of intermodal transit, the lab has created the Geospatial Intermodal Freight Transportation model, or GIFT, a Geographic Information System-based modeling program jointly developed with the University of Delaware that evaluates the environmental impacts of goods movement. The system utilizes mapping technology similar to Google Maps to evaluate shipping routes using different or multiple modes of transportation and then calculates the cost, time, and emissions for each route mapped.

GIFT allows shippers and policy makers to identify the easiest ways to move freight throughout the country, and properly assess the impact of the incorporation of different modes on cost, travel time, and the environment.

The model is unique in that it allows decision makers to model freight transport in multiple modes, including roads, water, and rail. Previous systems of this type were able to focus on only one mode of transit, reducing the accuracy of the models created and ignoring the potential economic, energy, and environmental benefits of intermodal freight transport.

"GIFT allows for a broader analysis of the benefits of intermodal transit by measuring how traditional supply routes can be made 'greener' through the addition of alternative transit modes whether they be truck, ship, or rail," adds Hawker. "It also provides data on the impact of current freight routes on energy use and emissions so planners can more properly assess how goods movement impacts the environment."

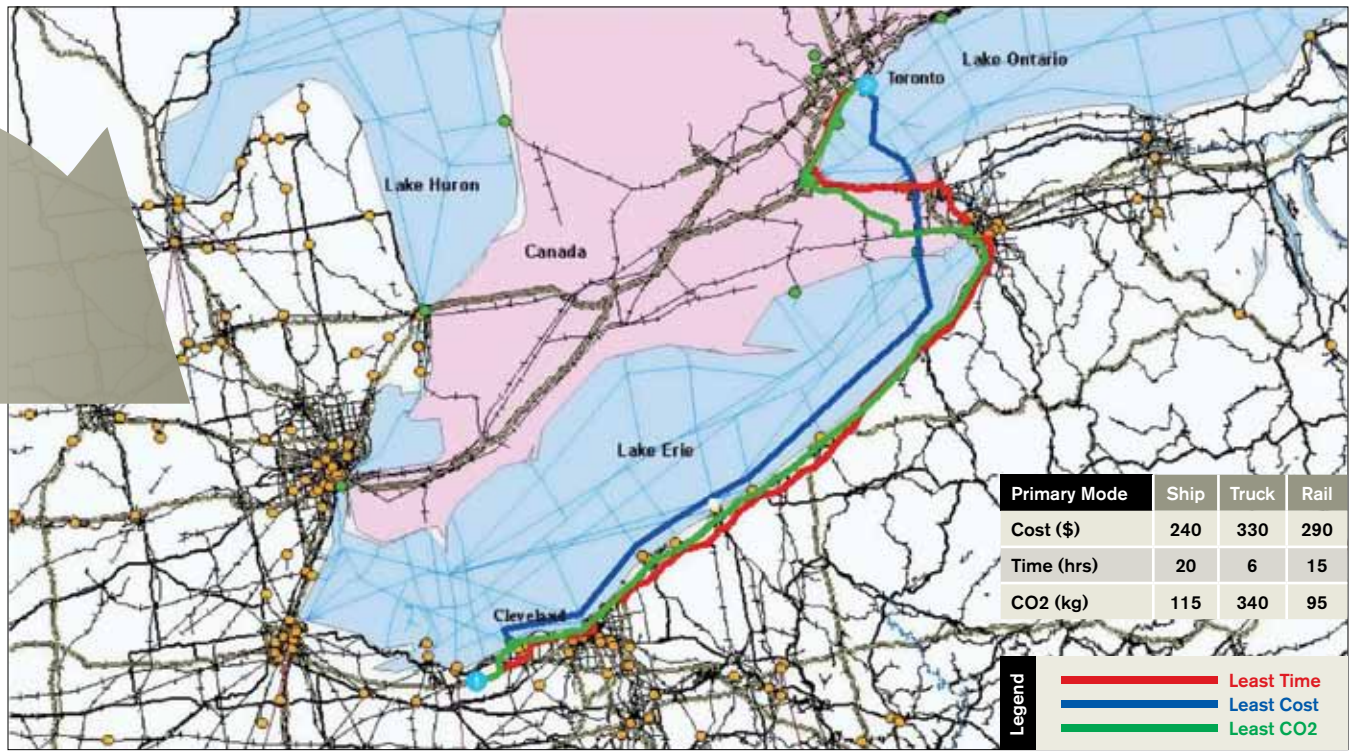
Lab researchers are currently using GIFT to assist government agencies in improving freight transportation planning. Researchers are also working to assess broader transportation-related issues, such as the health impacts of freight transportation and opportunities to improve disaster management modeling.

Improving Transportation Policy

Using the GIFT model, LECDM worked with the Great Lakes Maritime Research Institute to analyze the energy and environmental impacts of freight transit in the Great Lakes region. The study modeled the transportation of goods from Cleveland to Toronto by rail, ship, and truck and evaluated the differences between the modes in terms of cost, time, and emissions. The results illustrate the difficulties facing transportation policy makers and the need for intermodal methods in moving freight.

"Compared to a truck route, a water route through the Great Lakes cost less and released fewer greenhouse gases, but it took over twice as long for delivery," Hawker says. "The truck route was quicker than the rail or water routes but also the most polluting. Given this, none of the three modes by themselves is optimal."

However, by using the GIFT model, the decision maker could evaluate an



Providing Better Tools for Decision Makers: GIFT can model the transport of a shipment between two cities to illustrate the optimal routes and modes available, allowing planners and policy makers to more accurately analyze cost, time, and environmental considerations for freight transport.

intermodal route that meets economic, environmental, and energy goals, and generate maps that identify how and where each mode of transportation is employed.

"The data provides quantifiable evidence of the benefits of intermodal transportation and illustrates how modeling can be used by government agencies or companies to evaluate the best method for moving freight from city to city," Hawker continues.

The lab has followed up on this work by contracting with the state of California to assist in an assessment of its freight transportation system. The research will help California develop an overall environmental "footprint" of goods movement within the state. According to the U.S. Department of Commerce, about 40 percent of all U.S. containerized cargo comes through California ports.

"California is a major freight hub and a key player in efforts to reduce emissions in this sector," notes Korfmacher. "State planners will use GIFT to assess the impact of current policies on air quality and evaluate how enhanced use of intermodal transit may further decrease emissions."

LECDM is applying the results from its GIFT research to further understand the impact of freight transit on overall transportation emissions and to identify energy and environmental policies that might address pollution from this sector. For example, Winebrake is a member of two National Research Council committees that are advising federal regulators about the options for improved fuel economy standards and the use of alternative fuels for light-, medium-, and heavy-duty vehicles.

Modeling Health Impacts and Improving Disaster Management

Along with its transportation planning uses, GIFT is being utilized to assess the global health impact of shipping and support disaster management planning.

In 2007, Winebrake and Dr. James Corbett, professor of marine policy at the University of Delaware, published the first report to benchmark the number of annual deaths caused globally by pollution from marine vessels.

The study used GIFT and other models to correlate the global distribution of particulate matter—black carbon, sulfur, nitrogen, and organic particles—released from ships' smoke stacks with heart disease and lung cancer mortalities in adults. The results, published in *Environmental Science and Technology*, the journal of the American Chemical Society, indicate that approximately 60,000 people suffer premature mortality around the world each year from shipping-related emissions. Further work published in 2009 by the research team also shows that with the expected growth in shipping activity, the annual mortalities from ship emissions could reach 87,000 annually by 2012.

Research Enhancing Education: Brian Comer (center) and Arindam Ghosh (right), both master's degree students in RIT's department of science, technology, and society/public policy, are assisting Dr. James Winebrake (left), co-director of the Lab for Environmental Computing and Decision Making, in developing and implementing the GIFT model for use by transit planners and public policy makers.

Controlling Ship Emissions: RIT collaborated with the University of Delaware to conduct an analysis of the impact of ship emissions on human health. The team estimated that over 60,000 deaths per year can be linked to air pollution caused by global shipping. The researchers are now working with the International Maritime Organization to assist in the creation of global air quality standards for ship transport.

Winebrake is currently working with the International Maritime Organization, the United Nations entity that regulates global shipping, to further assess the overall environmental impacts of ship transit and assist the agency in developing proposed regulations aimed at reducing ship emissions.

"The problems of emissions from shipping are sizable and have largely been ignored by the international community," Winebrake adds. "This work will allow us to better understand the contributions that ships make to our atmospheric pollution problems and assist policy makers in better managing this system."

In addition, LECDM affiliate researcher Jennifer Schneider, professor of civil engineering technology, environmental management and safety, is using GIFT to improve emergency management planning and response to disasters. The research is assessing the effectiveness of current disaster management plans and assisting agencies to effectively incorporate transportation into their response.

This includes modeling the quickest routes between populated areas and creating alternate transportation plans using ship and rail to move people, food, and medicine if roads have been closed.

"A key facet of disaster management is the reliance on transportation routing," Schneider says. "Through the use of the GIFT model platform we can assist jurisdictions with properly mapping response routes and preparing alternatives to address unforeseen circumstances such as bridge destruction and flooding. GIFT will also be extended to allow identification of critical nodes in community transportation systems and assist local officials with community 'hardening' of critical infrastructure, a key focus of the U.S. Department of Homeland Security."

Environmental policy is a complex and often inexact science. Through the development of more robust modeling technologies, RIT's Lab for Environmental Computing and Decision Making is providing better information to policy makers, improving assessments of current regulation, and assisting in the development of policy reforms. The lab's researchers hope their work will increase the likelihood that future environmental laws will have their intended impact with reduced side effects.

"By providing policy makers with quantifiable data before decisions are made we can enhance the chance that their ultimate decisions will be successful," Winebrake adds.

On the Web

More information about this work and other related research is available online.
www.rit.edu/gccis/lecdm

Hydrogen Research Spurs Economy

Michael Haselkorn

Nabil Nasr

RIT's Golisano Institute for Sustainability is conducting a research demonstration initiative that seeks to improve the operation of hydrogen-powered vehicles and increase public understanding of hydrogen fuel.

A fully operational hydrogen fueling station was recently unveiled on the RIT campus. The station is being used to supply hydrogen to some of RIT's Facilities Management and Public Safety vehicles. GIS engineers are analyzing the vehicles to assess the effect of hydrogen on engine performance, component wear, fuel efficiency, and overall environmental impact, which will assist organizations investigating the use of hydrogen fuel and help designers improve future vehicle systems.

The County of Monroe and General Motors have access to the station to fuel their hydrogen vehicle fleets. RIT is also collaborating with these organizations to enhance public understanding of hydrogen fuel through a series of educational forums featuring GM's hydrogen demonstration vehicle, the Chevy Equinox.

"Hydrogen fuel has the ability to become a central alternative to fossil fuel. This project will provide critical information that will assist designers in improving hydrogen transportation," notes Dr. Nabil Nasr, director of the Golisano Institute for Sustainability.

"The research will also assist the public in learning more about the technology and enhance hydrogen's development as an alternative fuel source," adds Dr. Michael Haselkorn, research faculty at the institute and one of the engineers on the project.

The initiative is being funded through a three-year grant from the New York State Energy Research and Development Authority and is a component of the state's Renewable Energy Initiative.

"These combined efforts will help transform our energy systems and promote the goals of both enhanced environmental quality and economic development," adds Haselkorn.

Station to Help Advance Hydrogen Technology: RIT's hydrogen fueling station was unveiled earlier this year during a ceremony featuring Francis J. Murray, President and CEO of the New York State Energy Research and Development Authority. The station fuels campus vehicles used by Facilities Management and Public Safety, as well as Monroe County and General Motors hydrogen vehicle fleets.

Dr. Destler's Green Vehicle Challenge

RIT President Bill Destler

If the day is right, you may find RIT's President Bill Destler riding his electric bike to work. Leading the way to a greener RIT, Dr. Destler challenged the RIT community to design and build a green vehicle that consumed less energy than his electric bike. The challenge was part of the university's Imagine RIT: Innovation and Creativity Festival.

To encourage creativity, the rules were simple—design a vehicle that will carry at least one person on the 3-mile route around campus while consuming less total energy per 150 lb. person than Destler's electric bike. Any form of energy could be used except human power.

The team whose vehicle used the least amount of energy would receive either $1,000 cash or one of Destler's prized antique banjos.

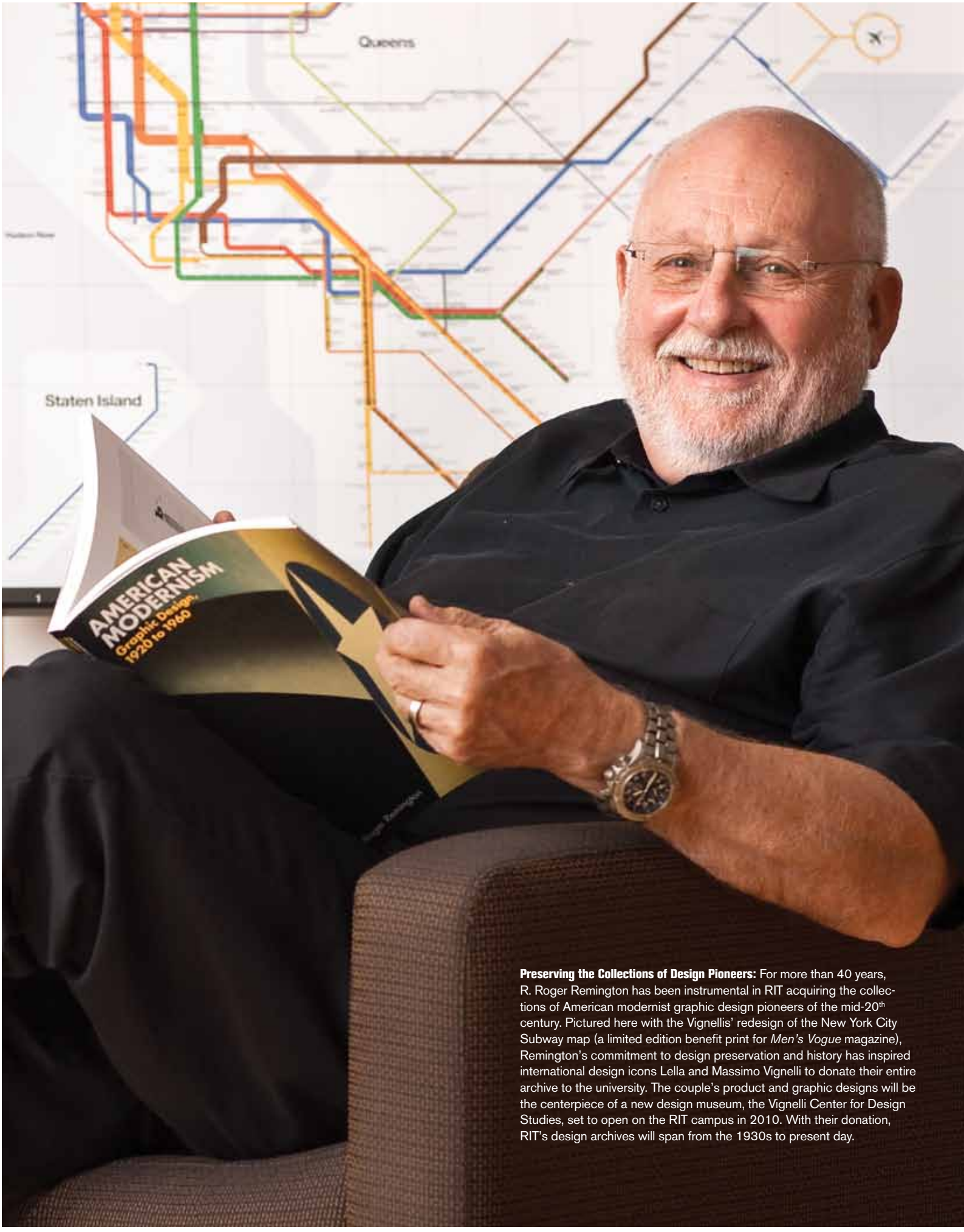
The challenge drew 10 teams, all of which used renewable energy sources—wind or solar—to charge their energy storage systems. Vehicle designs included mountain and recumbent bikes, an ice-racing sailboat, and a custom wind turbine. Four of the designs finished the race using less energy than Destler's electric bike.

A team from the department of Facilities Management shared the top prize with their solar-powered mountain bike, driven by staff member Scott Smith. The vehicle used 27.7-watt hours to complete the course as compared to 59.8-watt hours for Destler's electric bike—representing more than a 50% increase in energy efficiency. The solar-powered bike could store a maximum of 180 watts, which would allow the bike to travel up to 6 miles without any human power.

The co-winners, a group from the Center for Integrated Manufacturing Studies, designed their vehicle with a recumbent bike, and also charged their battery with solar energy in order to power the electric motor. The vehicle was driven by Abbey Donner, an industrial engineering student, used a total of 35.6-watt hours and had a maximum total power of 600 watts.

All of the vehicles demonstrated the feasibility of using totally renewable energy sources for short distance transportation needs. The challenge will be held again next year as part of the 2010 Imagine RIT: Innovation and Creativity Festival on Saturday, May 1, 2010.

Winning Vehicles: Abbey Donner (top) drives the vehicle engineered by a team from the Center for Integrated Manufacturing Studies. The recumbent bike, powered by an electric motor charged using solar power, used a total of 35.6-watt hours. Scott Smith (bottom) rides the solar-powered mountain bike designed by a team from Facilities Management. The vehicle used 27.7-watt hours to complete the course. The two teams shared the top prize for Dr. Destler's Green Vehicle Challenge.



Preserving the Collections of Design Pioneers: For more than 40 years, R. Roger Remington has been instrumental in RIT acquiring the collections of American modernist graphic design pioneers of the mid-20th century. Pictured here with the Vignellis' redesign of the New York City Subway map (a limited edition benefit print for *Men's Vogue* magazine), Remington's commitment to design preservation and history has inspired international design icons Lella and Massimo Vignelli to donate their entire archive to the university. The couple's product and graphic designs will be the centerpiece of a new design museum, the Vignelli Center for Design Studies, set to open on the RIT campus in 2010. With their donation, RIT's design archives will span from the 1930s to present day.

A Destination for the Study of Design

by Kelly Downs

RIT's School of Design is internationally recognized for its impressive design archives, featuring the work of pioneers spanning from the 1930s to the present.

Putting RIT on the Map as a Design Resource

R. Roger Remington believes that to fully understand present-day design concepts, the work of designers of the past must be examined. Remington, a design historian, teacher, and author, has worked throughout his 45-year career to make RIT an international resource of design history and theory.

"There is no other school, no other place that has this kind of resource not only for students, but for scholars from around the world," says Remington, RIT's Lella and Massimo Vignelli Distinguished Professor of Design.

It may be one of the best-kept secrets, but because of Remington's vision, RIT is home to the archives of such American Modernist graphic design pioneers as Lester Beall, Will Burtin, Cipe Pineles, Alvin Lustig, and William Golden.

The Lella and Massimo Vignelli Legacy

RIT is about to expand upon its impressive holdings of renowned designers with the addition of the archives of Lella and Massimo Vignelli. The couple's graphic and product designs are icons of international design. Their archive includes an extensive collection of original source materials, along with many examples of their finished work, including corporate identity campaigns, jewelry, silverware, and furniture.

The Vignellis are the visionaries behind such timeless classics as the Handkerchief Chair and the Paper Clip Table for Knoll, and the Stendig calendar. Massimo Vignelli recently designed a new map of the New York City subway system. They have designed corporate identity programs for Xerox, American Airlines, Bloomingdale's, Lancia, Cinzano, Knoll, and Ford Motor Co. They also designed furniture for Sunar, Rosenthal, Morphos, and Knoll.

Their collection will be the crown jewel in a design museum set to open in 2010 on the RIT campus. Named The Vignelli Center for Design Studies, the center will be a destination for students, faculty, professional designers, and scholars.

"This facility will be a global learning resource, bringing emphasis to design studies (history, theory, and criticism) as it extends the educational curricula at RIT," says Remington. "The Vignellis are to the world of design what Einstein was to physics. Through the scope and integrity of their work, the Vignellis have influenced design for more than four decades. They have always exemplified uncompromised excellence and greatness and now with the Vignelli Center at RIT we are partners in this history."

Lella and Massimo Vignelli: The Vignellis have donated their archives to RIT, which will be the centerpiece of the Vignelli Center for Design Studies. The center is set to open in summer 2010.

Collecting and Preserving a Generation of American Modernist Design Pioneers

A number of events in the 1980s sparked Remington's quest to obtain and preserve the collections of legendary designers.

"I started to become concerned that my graphic design students were lacking in their knowledge of the history of design and the history of their field. I started to do some work in integrating design history topics into my studio classes. I thought, 'wouldn't it be great to have original archival material for students to use as a reference?' It was about this time too that there was this movement in design education toward an emphasis in history."

It was through Remington's own research for a *Communication Arts* magazine article about designer Lester Beall that RIT came to acquire Beall's collection.

"I made contact with the Beall family and went to Connecticut to meet with Beall's widow Dorothy and his daughter Joanna. I discovered that Dorothy had his archive tucked away in corners of her condominium. She had been spending years sorting through his stuff. It was quite poignant."

Beall earned design reverence for his poster series in the late 1930s for the U.S. Government's Rural Electrification Administration (REA), part of the Department of Agriculture. His posters are considered icons of graphic design. Beall's other signature pieces are his numerous corporate identity programs and the publications he produced for pharmaceutical companies using montage and photomontage concepts.

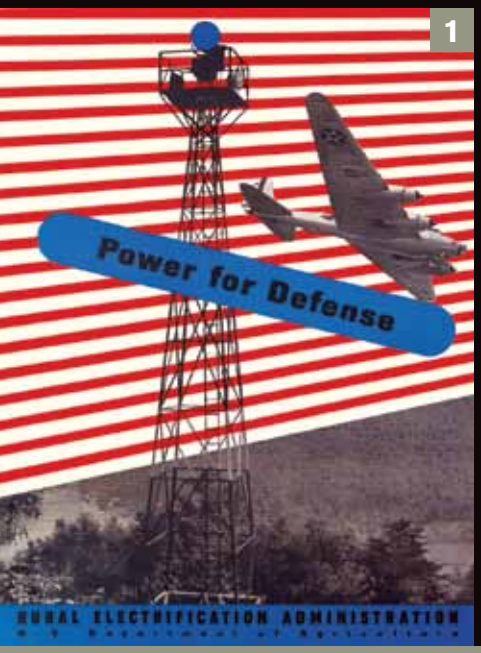
1958
Remington graduates from RIT with BFA

1960
College of Graphic Arts and Photography established

1963
Remington begins teaching at RIT

1969
Cary Graphic Arts Collection presented to RIT

1983
RIT hosts Coming of Age History of Design Conference



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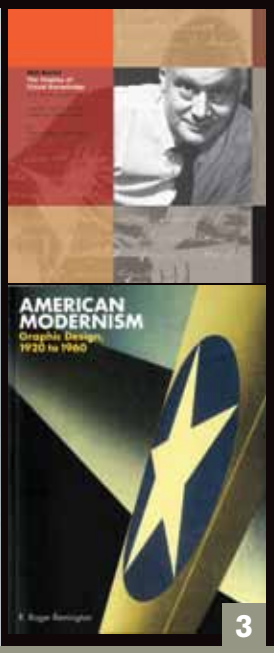

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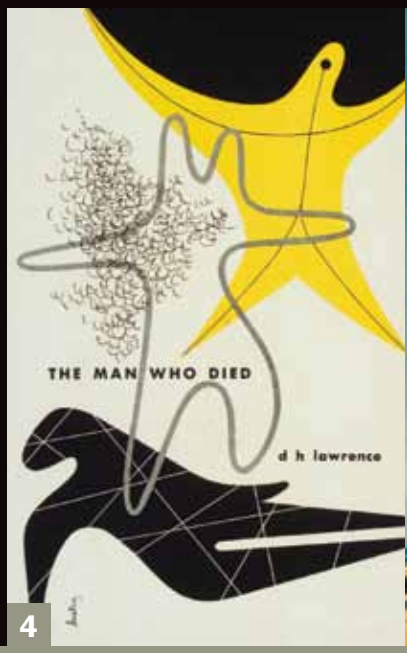

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1) Lester Beall:
Beall was a key design pioneer of the 20th century and an advocate of modernist graphic design. His collection, acquired in 1986, was the first in RIT's Graphic Design Archives.

2) Will Burtin:
Burtin is known for using design to interpret science whether it was his magazine covers or his three-dimensional designs. He created the walk-through models *The Brain* and *The Cell*.

3) History of Design:
Remington has used original source materials from RIT's Graphic Design Archives to author numerous books on modernist graphic design pioneers.

4) Alvin Lustig:
Lustig is known for his contributions to books and book jacket designs. His archive is one of more than 30 in RIT's Graphic Design Archives.

5) Cipe Pineles:
In the 1940s, modernist designer Cipe Pineles served as art director for *Seventeen* and *Glamour* magazines. Pineles was married to both William Golden and Will Burtin. The archives of all three design pioneers are at RIT.

Shortly after completing his article, Remington got a phone call from Beall's daughter asking if RIT wanted the archive. The answer was a resounding yes and Remington rented a truck and recruited several graduate students to help him haul the massive amounts of Beall's personal papers, business documents, and artwork back to RIT.

"Beall's was the very first collection donated to us in 1986 and the beginning of it all," says Remington. "It is still one of our largest collections and showpieces."

Remington received a grant from the National Endowment for the Arts to pay an archivist to rehouse and sort Beall's collection and establish a finding guide. Word soon spread that RIT was archiving material of Modernist designers.

"Other collections started to be offered to us. That started to add up and soon we had a critical mass of collections of design pioneers from this era of 1930s to 1950s. It makes me very proud that the work from the majority of this generation is here."

It's worth noting that RIT has acquired all of these collections, now totaling more than 30, at no cost. The estimated value of the combined collections is in the millions of dollars. They are collectively known as the Graphic Design Archives and are administered as a special collection within RIT's Cary Graphic Arts Collection, Wallace Library.

"It's completely been a labor of love, which is amazing," adds Remington.

Remington's Research and Writings

Throughout his career, Remington's own research focus has been on this generation of American Modernist design pioneers. It's the basis for Remington's four books on graphic design history.

He has authored *Nine Pioneers in American Graphic Design* (MIT Press), *Lester Beall: Trailblazer of American Graphic Design* (WW Norton), and *American Modernism: Graphic Design, 1920-1960* (Laurence King Publishers, London/Yale University Press). His most recent book, *Design and Science—The Life and Career of Will Burtin* (Lund Humphries), is co-authored with Robert S. P. Fripp.

"As the years go by, people start forgetting about these important pioneers and

1986 RIT acquires archive of Lester Beall

1989 Remington and Barbara Hodik co-author *Nine Pioneers in American Graphic Design*

1993 Acquisition of George Giusti archive

1998 School of Design formed

2000 RIT acquires archive of Will Burtin

2002 Massimo Vignelli awarded an honorary doctorate and Lella Vignelli awarded a President's Medal

2008 Remington inducted into Art Directors Club Hall of Fame

2010 Opening of Vignelli Center for Design Studies

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6) William Golden: Golden developed the iconic CBS Eye logo. He was considered the chief architect of the CBS Television Network identity program.

7) The Handkerchief Chair: The Vignellis are known for their product designs including furniture, dinnerware, jewelry, and clothing.

8) Corporate Identity: American Airlines introduced this corporate identity program in 1967. Other companies the Vignellis helped to brand are Bloomingdale's, Knoll, Lancia, and CIGA Hotels.

9) The Stendig Calendar: This calendar is a timeless classic created by the Vignellis. It's been published every year since 1966. The calendar will be a part of the Vignellis' archive at RIT.

10) Presidential Recognition: President Ronald Reagan presented the Vignellis with the first Presidential Design Award in 1985 for the U.S. National Park Service Publications Program.

the work they've done. The companies they worked for no longer exist. Their life stories need to be told. In writing my books, having the archives here made all the difference because I could easily get access to the original sketches, designs, and letters. These original source materials are important to my students and me. It's what brings my history classes to life."

The RIT Cary Graphic Arts Press has published three chapbooks on these mid-century graphic designers, two of which were written by Remington. *Will Burtin: The Display of Visual Knowledge* followed previous chapbooks *Lester Beall: Space, Time & Content,* and *Cipe Pineles: Two Remembrances.*

In the foreword of the inaugural chapbook, Massimo Vignelli writes: "History, theory and criticism: These were the passwords launched at the first conference of Graphic Design History at the Rochester Institute of Technology about 20 years ago. Until then, very little or nothing at all had been done to document and study the development of graphic design in the USA. Times were ripe and Roger Remington spearheaded the efforts."

The Vignellis—Longtime Friends and Supporters of RIT

In 1983, RIT hosted this national conference on design history and Massimo Vignelli delivered a keynote address. Remington's connection with the Vignellis has grown over nearly three decades and he considers them close, personal friends.

RIT awarded Massimo Vignelli an honorary doctorate degree in fine arts and Lella Vignelli a President's Medal in 2002. The two are longtime supporters of RIT's School of Design.

The Vignelli Center's gallery will exhibit permanent collections of their designs. Students and researchers can access their work in the building's archives. The center will also be a hub for multidisciplinary programming including new courses. For Remington, it's the programming possibilities that really excite him.

Vignelli Center's Programming Potential—From RIT to Across the Atlantic

"RIT's great potential is in its inter-

Groundbreaking: The Vignellis joined RIT leaders to break ground on the Vignelli Center for Design Studies in October 2008. The center will house the archives of Lella and Massimo Vignelli.

Rendering of The Vignelli Center for Design Studies: The center will be an international design resource for educational programming and research.

disciplinary work," says Remington. "With the opening of the center, I want to expand our offerings of interdisciplinary courses. I am working with Tim Engström, professor in the philosophy department, to develop a course tentatively called "The Philosophy of Design from Plato to Vignelli." The Vignelli Center will co-sponsor with David Pankow, curator of the Cary Graphic Arts Collection, a new course, "Ten Books in Ten Weeks."

Pankow adds, "The idea of the course is to choose 10 books that influenced 20th century graphic design because of their innovative arrangements of text and image. Ten people will speak about the books' significance. For example, the first book in the lecture series will be the *Kelmscott Chaucer*, designed by William Morris. The book was printed in 1896 and had a profound influence on 20th century design and typography. Remington himself will be one of the course presenters and will speak on *Mise en page*, a famous book on layout published in 1931."

Remington believes the educational programming, research, and the Vignelli Collection will move the university into a position of major prominence in the world of professional design.

Richard Grefé of the American Institute of Graphic Arts says, "The Vignelli Center for Design Studies will be instrumental in defining the role of design in society and commerce ... RIT's commitment to archiving the artifacts of creativity will allow future generations to appreciate and build on the contributions of the Vignellis and other designers in an unprecedented way."

The Vignelli Center will extend RIT's influence to global design venues and complement the longstanding international exchange programs with the Dessau Department of Design, Anhalt University of Applied Sciences in Dessau, Germany, and in Copenhagen, Denmark.

Remington has begun talks with the Royal College of Art in London on potential collaborative initiatives. Jeremy Ainsley, professor of design history and a director of research at the Royal College of Art, came to RIT this spring to conduct research. He was impressed with the university's existing archives and the new center's arrival.

"The Vignelli Center for Design Studies is a very exciting development for the state of design studies internationally," says Ainsley. "Already, RIT is on the academic and research map for design history, theory, and criticism because of the programs of study available, but also as a result of the special opportunities for research and scholarship offered by the holdings and staff expertise of the Cary Graphic Arts Collection and the Graphic Design Archive at the Wallace Library."

A Shared Vision for Design Excellence

Remington credits his RIT colleagues in helping to elevate the university's reputation for design excellence.

"I couldn't do what I do here without people that share this vision like Kari Horowicz (art and photography librarian, RIT Libraries) and David Pankow. I've never had to convince them that this is an important thing to do."

"The 20th century graphic design archives we have accumulated here have established RIT as one of the best resources in the world for Modernist design studies. RIT is without peer in this area. The Graphic Design Archives, the Vignelli Collection, and the Cary Collection represent an astonishing continuum of typography and design from the early stages of bookmaking, advertising, and design to the present," says Pankow.

On the Web

More information about this work and other related research is available online.
http://library.rit.edu/cary/
www.rrogerremington.com

Achieving Artistic Fidelity in Black-and-White Digital Printing


David Pankow


Nitin Sampat


Franz Sigg

The unique imaging science and art capabilities at RIT create a perfect equation to push the limits of digital printing.

Expanding on prior work that used the HP Indigo 5500 Digital Press to achieve near absolute fidelity in the color reproductions of posters, a cross-disciplinary team from the College of Imaging Arts and Sciences, RIT Cary Graphic Arts Press, and Printing Applications Laboratory (PAL) has now created a process that uses the press to produce black-and-white photography while maintaining near absolute fidelity.

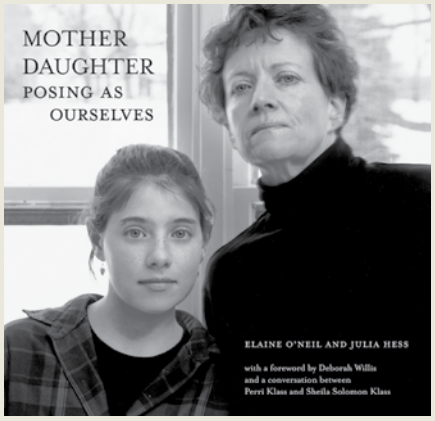
"As far as we can tell, this approach has never been done before. The competitive photo book market, along with the interesting technical challenges, made this an attractive opportunity for RIT," says Bill Garno, director of PAL.

"Creating black-and-white reproductions on a digital press presents an even greater challenge than color," says David Pankow, director of the RIT Cary Graphics Art Press. "With black and white you need to be able to capture all of the smooth tonal richness of the originals, in addition to the technical challenges of maintaining neutrality, as well as good midtone, highlight, and shadow details."

Using the HP Indigo 5500 Press, the team developed a process that uses a custom four-color ink set that consists of black and three grays (GGGK), instead of the traditional black and three other colors (CMYK). One of the features of the HP Indigo Press is the ability for end-users to mix custom inks and, in this case, develop a custom palette of grays—similar to traditional duotone or tritone offset printing where several grays provide an extended range.

Nitin Sampat, associate professor in the School of Photographic Arts and Sciences, Franz Sigg, research scientist at the School of Print Media, and Jeremy Vanslette, manager of the Digital Printing Lab at PAL, conducted extensive characterization tests of the equipment, designed the custom inks, and worked on custom software to develop a process that enabled high-quality reproductions of black-and-white silver halide originals.

The novel process was developed in collaboration with photographer Elaine O'Neil, retired professor of the College of Imaging Arts and Sciences, for the publishing of her photographic book called *MOTHER DAUGHTER Posing as Ourselves*. "My concern as an artist has always been that when you are dealing with ink on paper, as opposed to photographic emulsion, at some point it has always been a compromise. In this case, the aesthetic quality of looking at the book is as close to the real thing as anything I have ever seen," says O'Neil.



First Production: The novel quadtone black-and-white process was developed specifically for the production of *MOTHER DAUGHTER Posing as Ourselves*. The book is available online on the Cary Graphic Arts Press website: http://carypress.rit.edu/.

"This is a perfect example of what can happen when the left brain and right brain come together," says Garno. "The results are remarkable and this speaks to the unbelievable amount of cooperation, commitment, and intensity from everyone on the project."

Celebrating 25 Big Shots


Bill DuBois


Michael Peres


Dawn Tower DuBois

Portrait photographer: J. Retallack

December 4, 1987, the Big Shot debuted at Highland Hospital in Rochester, N.Y. Since that time it has traveled the world from Dubrovnik, Croatia, to Stockholm, Sweden, and this past September the 25th Big Shot was captured at the Smithsonian's National Museum of the American Indian in Washington, D.C.

"The Big Shot provides a way to teach students how to correctly use and balance electronic flash through this extraordinary community event," says Dawn Tower DuBois, professor at RIT's National Technical Institute for the Deaf.

What makes the Big Shot so powerful are the participants. Students and anyone in the community who wants to participate can help light up the scene. Everyone uses his or her own lighting source—anything from a handheld flashlight to electronic flash equipment. "When students approach the magnitude of the subject, they are able to realize the power in numbers. If you put 10 flash units together, you get 10 times the light. It sounds simple, but to have students step into the role of a flash photographer allows them to experience and think through the challenge," explains Bill DuBois, professor in the School of Photographic Arts and Sciences.

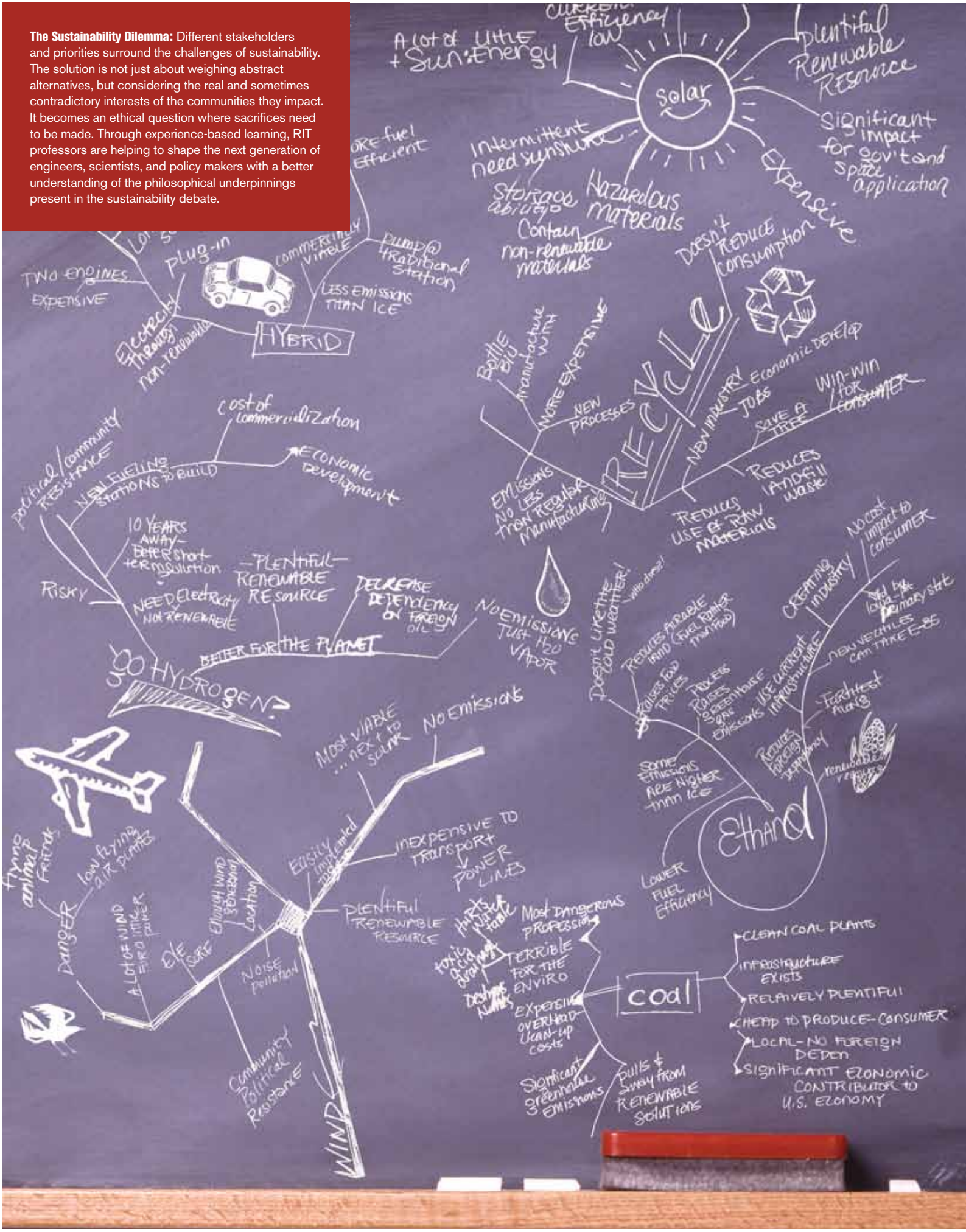
Take 25: Photographed September 26, 2009, RIT's 25th Big Shot was captured in Washington, D.C., at the Smithsonian's National Museum of the American Indian.

Prior to the event, students and organizers choreograph the shot, considering the different characteristics of the subject, such as glass, concrete, stone, rain, weather, and the surroundings. However, there are many variables that can't be planned for—perhaps most importantly, how many people will show up.

The Big Shot at the Smithsonian's National Museum of the American Indian drew over 800 volunteers. The crowd was divided into 11 teams, placing flashes in one area for neutral color, and flashlights in other areas for warmer effects. "It becomes sort of an organized chaos," says Michael Peres, professor in the School of Photographic Arts and Sciences.

A celebration of the 25 Big Shots has been compiled into a book entitled *The RIT Big Shot*, published through RIT's Open Publishing Lab.

The Sustainability Dilemma: Different stakeholders and priorities surround the challenges of sustainability. The solution is not just about weighing abstract alternatives, but considering the real and sometimes contradictory interests of the communities they impact. It becomes an ethical question where sacrifices need to be made. Through experience-based learning, RIT professors are helping to shape the next generation of engineers, scientists, and policy makers with a better understanding of the philosophical underpinnings present in the sustainability debate.



Sustainability Ethics

by Kara Teske

Solutions to address the challenges of sustainability are often bound by contrasting viewpoints. Professors at RIT are developing new educational methods to help influence decisions of future policy makers and innovators.

A Personal Decision—A Global Impact

Every day new evidence reveals the deterioration of renewable resources, the destruction of habitat, and the impact of industrial production on society. In response, engineers, policy makers, environmentalists, and innovators across the world are attempting to develop better ways of using resources and meeting the needs of the Earth's population without negatively impacting the planet for future generations.

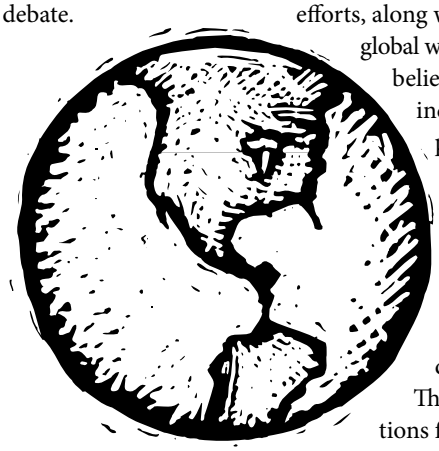
However, for these goals to become a reality and less of an ideology, people, businesses, and governments will be required to make sacrifices for the benefit of future generations and communities. How can sustainability be truly implemented if the actual benefits are years away and do not directly affect today's decision makers? This dilemma is one of the central questions of sustainability ethics.

Faculty members at RIT are developing answers to this question by organizing an international conference and by developing new educational methods in sustainability ethics that will help guide students' problem solving and decision making skills and imbue our next generation of engineers, scientists, and policy makers with a better understanding of the philosophical underpinnings present in the sustainability debate.

Thought Leader in Sustainability Ethics: Wade Robison, Ezra A. Hale Professor in Applied Ethics, co-directed an international conference on sustainability ethics that examined the theoretical and scientific sides of sustainability.

Uncovering the Issue

Last spring, RIT hosted a conference on sustainability ethics that brought together five internationally recognized experts to examine the role ethics plays in sustainability. Co-directed by Dr. Ryne Raffaelle, affiliate professor at RIT and director of the National Center for Photovoltaics, Dr. Wade Robison, Ezra A. Hale Professor in Applied Ethics, and Dr. Evan Selinger, associate professor of philosophy, the conference posed five fundamental questions central to the sustainability dilemma.



First, '*Why is sustainability a contested concept?*' "Sustainability is about opposites; it is about tensions. And therein lies part of the contest," says Dr. William Shutkin, director of sustainable development and chair of sustainable development at the University of Colorado at Boulder.

For example, earlier this year, Dr. James E. Hansen, director of NASA Goddard Institute for Space Studies, well known for one of the world's first models that predicted much of what is happening with the climate, protested against mountaintop coal mining in West Virginia. His recent modeling efforts, along with other scientists' observations, conclude global warming is far greater than he suspected. Hansen believes that unless immediate action is taken, including the shutdown of all the world's coal plants within the next two decades, the planet will experience a devastating climate change.

"This is a classic example of the challenges society is facing that hinder the ability to address these critical issues," says Robison. "Most people who agree with the data that supports Hansen's observations disagree with his approach to the solution. There are obvious economic and social implications for Hansen's view of simply shutting down the coal mines. The data shows coal mining is not sustainable; the question is what to do about it."

"It is not just about possible alternatives considered in the abstract, but the considerations of real, local interests," explains Selinger. "The local community asks, 'Why should we have to give up our livelihood to solve this global problem when other people aren't required to make equivalent sacrifices?' People

Wind

Wind power can be used to generate electricity while emitting virtually no greenhouse gases. However, wind farms require significant land mass and can intrude on the surrounding landscape and residents. So, if it's not in my backyard, then where?

Weighing the Issue

- ✓ Emits virtually zero greenhouse gases
- ✓ Inexpensive to generate and transport power
- ✓ Easy to implement since current power grid can be utilized
- ✓ Plentiful natural resource

- ✗ Requires the clearing of large woodland and grass areas to construct wind farms
- ✗ Potential danger for birds and low-flying airplanes
- ✗ Tarnishes the natural landscape and creates significant noise pollution
- ✗ Installation costs high

Hybrid Vehicles

Hybrid vehicles offer a short-term solution to reduce dependency on foreign oil while reducing emissions, but are they worth the cost?

Weighing the Issue

- ✓ Decreases dependence on gasoline/ foreign oil
- ✓ Increased fuel efficiency and reduced fuel costs by using electricity and stored energy
- ✓ Reduced emissions compared to internal combustion engine (ICE)
- ✓ Current fueling station infrastructure can be used

- ✗ Expensive to manufacture since hybrids require two engines—one powered by electricity, one powered by gasoline
- ✗ Expensive to own and maintain; cost savings from fuel can take years to recoup
- ✗ Electricity generation powered through nonrenewable source

Coal

Coal represents a significant part of the U.S. economy, but has severe environmental implications. What will it take to preserve the planet and the economy?

Weighing the Issue

- ✓ Significant contributor to U.S. economy; every coal mining job creates an estimated five to eight jobs somewhere else in the economy
- ✓ Produced domestically, no foreign dependency
- ✓ Infrastructure already exists
- ✓ Livelihood for thousands of Americans
- ✓ Inexpensive for consumer

- ✗ Damaging to the environment—impacts soil, water table, and greenhouse gases
- ✗ Toxic acid mine drainage pollutes nearby streams and soil when mines are left abandoned
- ✗ Mine blasts can destroy nearby property
- ✗ Expensive to operate coal mines as a result of requirements passed by legislation

are forced to confront the question of whether their primary obligations are to their families, their local neighbors, or to the global community."

The second question of the conference examined different viewpoints, and asked, '*Why is their definition of sustainability better than alternative accounts?*'

When it comes to sustainability, different stakeholders bound the problem in different ways and define it differently. Take, for example, the Precautionary Principle, which states that where there is risk of serious harm, lack of full scientific certainty should not be a reason to not take preventive measures. However, what counts as harm, what counts as risk, and how to calculate these risks are all subjective concepts that hamper efforts to address the problem.

Industrialists may see the Precautionary Principle as overly conservative, causing a reduction in economic development that countries need to remain viable and sustainable. However, environmentalists often call for additional precautions to prevent unintended environmental consequences even if it hampers the standard of living for individual communities in the short-run. Policy makers are then required to sift through these differing viewpoints to best meet the needs of their constituencies, needs that may often be different from the needs of communities in other regions or countries. So, a mayor in a coal mining community in West Virginia may push to prevent restrictions on coal to protect the sustainability of his community even if the long-term impact of this decision may actually hurt his constituents.

Sustainability—An Ethical Decision

Sustainability has become part of the mainstream media jargon, with slogans like "Go Green" and "Think Globally, Act Locally." But, behind these buzzwords, people are being asked to take responsibility and make decisions that allow them to meet their needs without compromising the ability of future generations to meet their own needs. It becomes an ethical dilemma—should people make sacrifices today for the benefit of future generations?

This leads to the third conference question: '*What is sustainability ethics?*' For years, people have been studying business ethics and environmental ethics; sustainability ethics contains issues from both of these sub-disciplines. So, is sustainability ethics an extension of

Solar

The sun is the most abundant energy source on the planet. What will it take to translate this into mass power generation?

Weighing the Issue

- ✓ Solar emits zero emissions
- ✓ Most abundant energy source
- ✓ No cost to generate power once installed
- ✗ Requires a tremendous amount of sun to generate a little energy
- ✗ Intermittency requires there to be significant power storage capabilities
- ✗ Devices contain some hazardous materials and nonrenewable resources
- ✗ Development and installation of solar devices is expensive

Hydrogen

Hydrogen fuel cells may hold the future for the next generation of automotive fuel, offering substantial benefits for the environment. What would this mean for the current fueling infrastructure? What about the risks?

Weighing the Issue

- ✓ Decreases dependency on foreign oil
- ✓ Plentiful renewable resource
- ✓ Supports economic development, creating new industry and jobs
- ✓ Only emission is water vapor
- ✗ New fueling infrastructure required
- ✗ High cost of commercialization
- ✗ Risk factors of explosion

Ethanol

The natural resources growing in America's farmlands can be used to generate renewable energy. But is it as efficient, and what does that mean to the cost of food?

Weighing the Issue

- ✓ Can be used by most gasoline vehicles in concentrations up to 10%
- ✓ Renewable resources reduces dependency on foreign oil
- ✓ Supports agriculture and rural economic development in the U.S.
- ✗ Lower fuel efficiency
- ✗ Some emissions are actually higher than internal combustion engines
- ✗ Reduces arable land and raises food prices
- ✗ Corn farming and corn-based ethanol production can use nearly as much energy to produce as it supplies

these, or something completely new?

Robison compares the idea of sustainability ethics to the evolution of privacy. Today, privacy is an important legal concept, but before 1893 the idea of privacy as a right did not exist. It took a legal case of a woman who found her photograph on a bag of flour without permission to establish the right to privacy.

"This historical story reminds us that privacy had to be invented into law; until this case no one thought about privacy in this way. Looking back you can identify all the situations and cases in which the right to privacy may have applied. And, perhaps we are seeing a similar evolution with sustainability ethics. It is not necessarily a new idea, but a realization and understanding of concepts that already exist," explains Robison.

The issues of sustainability are not just technical issues but issues of values. Sustainability is not just about making more energy-efficient things or finding ways to reuse things so they last longer—that is not the full story. Within all of these challenges is a philosophical question that may require people to make sacrifices that might not be a direct benefit to them.

Influencing Sustainability

The experts were finally asked, '*What contributions can philosophy make?*' and '*What are the most important topics of future inquiry?*'

"Philosophers can urge practitioners, policy makers, and citizens to avoid the pitfalls of objectivism and orthodoxy and encourage curiosity to experiment with different approaches and continuously strive to improve and refine our latest knowledge, methodologies, and technologies in light of the feedback we receive from physical and social reality," says Shutkin.

To further analyze and address these questions, faculty members at RIT's Golisano Institute for Sustainability (GIS) are developing a series of educational and research programs designed to promote sustainability ethics as an academic discipline.

Sustainability ethics is a key component of the sustainability Ph.D. curriculum, which includes a core course on the subject, taught by Selinger. In addition, through a grant sponsored by the

Experience-based Learning: In partnership with the University of Arizona, Dr. Evan Selinger (left), associate professor of philosophy, and Dr. Thomas Seager (right), associate professor at GIS, are developing an experiential-based lab to expand the sustainability ethics curriculum at RIT. The class takes classic sustainability problems and places students in the position of an environmentalist, innovator, or regulator so students can experience what it is like to be constrained by interests that drive those roles.

National Science Foundation and in partnership with the University of Arizona, Dr. Thomas Seager, associate professor at GIS, and Selinger, are working to develop an experiential-based lab to expand the sustainability ethics curriculum at RIT.

"Traditional means of teaching ethics through abstract case studies will not teach students how to handle the competing viewpoints of sustainability. Additionally, students, especially engineers, learn best in experimental and experiential environments where they are able to problem solve and see first hand what happens. This is the vision that has helped to shape the sustainability ethics curriculum at RIT," explains Seager.

"By creating a virtual environment, students can anonymously interact and experiment with different ethical strategies with the only consequence being reflected in their grade. It provides students with a safe environment to experiment in and allows students to learn faster in a more robust way," adds Seager.

RIT's sustainability ethics course work looks at classic sustainability problems and places students in the position of an environmentalist, innovator, or regulator. Students come in with their own pre-existing ideas of what is right and wrong and through the deliberative cooperative process learn about classic ethical concepts like fairness and justice. Students experience what it is like to be constrained by interests that drive those roles and what kind of deliberations arise.

"The problems are not solvable in the traditional sense—there isn't one right answer, which for engineers can be frustrating," notes Seager. With each problem there is a simple mathematical representation and some solutions will naturally be better than others, but there may be multiple workable answers.

"Students will fail, they will get frustrated, they will see the right answer but in order to achieve it they will need to convince everyone of their vision, and that is the sustainability problem," says Seager. "We know how to reduce energy use, we know how to be greener for the environment, but the challenge is turning it into a reality.

"At RIT, our goal is provide our students with the education and experiences that will allow them to become well-rounded innovators, so they are not just the best engineers, but are guided by a solid ethical basis for the betterment of their career and the world," he adds.

Broader Outreach

GIS continues to build on these efforts to bring awareness and understanding of the ethical implications of sustainability. The viewpoints of the experts shared at the sustainability conference are being compiled into a book entitled *5 Questions about Sustainability Ethics*, expected to be released in the spring of 2010.

Following the development of the experience-based lab for sustainability ethics, the team will host a workshop to train other universities throughout North America on how to deliver the course.

In addition, Selinger, in collaboration with Danish philosophers and the European Union, is co-directing an international sustainability conference next year in Copenhagen.

On the Web

More information about this work and other related research is available online.
www.rit.edu/fa/ritgreen
http://eselinger.org

Environmental and Economic Systems Management


Amit Batabyal

Dr. Amit Batabyal, the Arthur J. Gosnell Professor of Economics in the College of Liberal Arts, is using dynamic and stochastic modeling techniques to create theoretical models that can assist in preserving and protecting American rangelands, advancing our understanding of how to manage invasive species, and promoting sustainable economic development in the developing world.

"Economic modeling has traditionally been used to maximize either the utility of individuals or the profits emanating from the optimal management of exhaustible and renewable resources," notes Batabyal. "However, these models do not work well when addressing complex problems in ever-changing environments, features that routinely characterize ecological-economic systems such as rangelands."

In response, Batabyal has adapted a series of stochastic modeling techniques from the operations research literature and has used them to analyze ecological-economic systems for which both data and outcomes are uncertain. In the case of rangelands, these modeling techniques are designed to assist managers to better assess how shocks to the system, such as floods or droughts, will impact grassland, cattle production, and the ultimate survivability of the habitat for future seasons.

"These models will provide more guidance to ranchers on how to maximize profit and yet maintain resilience for the long term, while also assisting environmentalists in preserving the often fragile ecosystems in the American West," Batabyal adds.

Batabyal's research in rangeland management culminated in the book *Stochastic Modeling in Range Management: Selected Essays*, published by Nova Science. It also earned him the "Outstanding Achievement in Research Award" from the Society for Range Management.

Batabyal is now developing stochastic models to better manage the introduction of invasive species in new habitats, through research funded by the U.S. Department of Agriculture. He is also researching ways in which developing countries might better manage their natural resources. Some of this work appeared in the book *Dynamic and Stochastic Approaches to the Environment and Economic Development*, published in 2008.

Through the graduate course The Economics of Sustainability, which he co-developed as a core course within RIT's doctoral program in sustainability, Batabyal is working to assist future scientists and engineers in understanding the interactions between ecology and economics.

"These research and education programs will give future policy makers and managers a better understanding of the ways in which today's actions will impact future yields, productivity, and the overall sustainability of resource systems," Batabyal says.

Rangeland Management: Amit Batabyal, Arthur J. Gosnell Professor of Economics, is using dynamic and stochastic modeling techniques to create theoretical models designed to assist managers to better assess how shocks to the system, such as floods or droughts, will impact grassland, cattle production, and the ultimate survivability of the habitat for future seasons.

Photo courtesy of USDA Natural Resources Conservation Service

Rochester Clean Energy Education Partnership


Dan Johnson


James Myers

Earlier this year, the New York State Energy and Research Development Authority (NYSERDA), RIT, and Monroe Community College (MCC) established the Rochester Clean Energy Education Partnership.

This collaboration brings together RIT's College of Applied Science and Technology (CAST) and College of Science (COS) with the Workforce Development division of Monroe Community College to create new college-level courses, professional development initiatives, and training programs in alternative energy technology and clean energy development. The courses, offered to undergraduates, graduates, and professional engineers, will promote the continued incorporation of clean energy concepts in traditional engineering and science classes.

"We are engaged with MCC to create a body of knowledge around clean energy technologies, specifically in the areas of wind and solar power, photovoltaics, and fuel cell development," says Dr. James Myers, director of the Center for Multidisciplinary Studies in CAST and one of the project's directors.

Five courses are being developed for the program: Principles of Clean Energy Technology, Fuel Cell Power Systems, Fuel Cell Science, Power Systems, and Wind Power Systems.

"The course work will be used for students in CAST and COS," says Dan Johnson, chairperson of the CAST manufacturing and mechanical engineering technology/packaging science department. RIT faculty from the colleges are currently creating the new courses to serve as technical electives, and will be available to students during the 2009-2010 academic year.

"The classes will also serve as the basis for modules that will be developed at MCC in these areas, but focused on skilled trades programming for current production workers in the field," adds Johnson. "Elements of the courses will be worked into modules to develop curricula for skilled trades, particularly HVAC apprentices and electricians, who will work for organizations focusing on renewable energies," says Johnson.

Professional development courses will also include training on new process improvements in materials development, packaging, and energy efficiencies with an emphasis on improving recyclability and reducing overall energy usage.

"This is just the beginning of what CAST will be doing in this area," says Myers. "The college intends to continue the multidisciplinary approach to renewable energies and the technologies needed to support this growing field. Resources at RIT make this an ideal location and approach," he added. The team also anticipates the development of a new clean energy lab on campus to eventually interface with the systems and energy grids used in corporations.

NYSERDA Helps to Create Clean Energy Partnership: Francis J. Murray Jr., President and CEO of the New York State Energy Research and Development Authority, announced a new partnership that brings together RIT and Monroe Community College to create new college-level courses and professional and training programs in alternative energy technology and clean energy development.

Research Awards and Honors

by William Dube

RIT values the contributions of its faculty, staff, and students across all colleges and centers. Below we highlight members of the RIT community who have received significant internal, national, or international recognition this year.

Trustees Scholarship Awards

The Education Core Committee of the RIT Board of Trustees awards up to three Trustees Scholarship awards each year to RIT faculty who demonstrate outstanding academic scholarship. In 2009, two RIT professors were recognized with the award:

Michael Stinson, professor of research and education studies at the National Technical Institute for the Deaf, is considered a pioneer in the development of supportive technology for the deaf and hard of hearing. He is the inventor of the C-Print speech-to-text system and has received the Outstanding Research on the Education of Deaf Persons Award from the American Educational Research Association and the NTID National Advisory Group's Outstanding Service Award.

John Schott, Frederick and Anna B. Weidman Chaired Professor in the Chester F. Carlson Center for Imaging Science, is a recognized expert in remote sensing, digital imaging, and detector design. He served as a lead scientist for NASA's Landsat 7 Science Team and is currently on the Intelligence Science Board for the Director of National Intelligence. His latest book, *Remote Sensing: The Image Chain Approach, 2nd Edition*, was published by Oxford University Press in 2007.

Fulbright Scholars

The Fulbright program, established in 1946 and sponsored by the U.S. Department of State, is the largest U.S. international exchange program offering advanced research and teaching opportunities for students and scholars in more than 150 countries worldwide.

RIT faculty members Willie Osterman and Roberley Bell and students Christie Ong and Stephanie Haas received Fulbright awards in 2009.

Willie Osterman, professor of photography in the School of Photographic Arts and Sciences, used his Fulbright award to assist the University of Zagreb in developing curriculum and course work related to their new photography program. It is the first degree in photography created at a Croatian university. Osterman also plans to photograph and exhibit a visual history of Zagreb, focusing on the city's art and architecture.

Roberley Bell, professor of foundations in the College of Imaging Arts and Sciences, has received a Fulbright Award to Turkey. Bell will spend next spring at Kadir Has University in Istanbul teaching courses about public art and public space, specifically on urban settings and spatial perceptions. She also plans to do projects with students on mapping and public community intervention that will engage locales within Istanbul.

Stephanie Haas won a Fulbright while a student in the fine art photography program at RIT. Haas used the award to conduct research in sustainability and environmental consciousness in Oslo, Norway. The project included portraits and interviews with Norwegians to develop a better understanding of citizen knowledge and enthusiasm for sustainable development. Haas hopes the results will better inform Norwegian and international policy makers as they address issues ranging from global warming to natural resource depletion to the use of the world's oceans.

Christie Ong, a recent advertising and public relations graduate in the department of communication, is only the third student from NTID to be awarded the Fulbright in Deaf Studies. She is currently spending a year in Italy creating a support network for Italian parents with deaf and hard-of-hearing children. This includes the development of an Italian chapter of Hands and Voices, an American-based nonprofit that provides services and training related to the deaf and hard of hearing for both parents and service professionals such as doctors and teachers. In addition to the Fulbright,

Ong was named to the *USA TODAY* All-USA College Academic Honorable Mention Team in 2009.

National and International Recognition

Frank Romano, professor emeritus in the School of Print Media, has been named an Ipex 2010 Champion of Print. The award goes to leading figures in the printing industry and is being used to promote the quadrennial international printing exposition and trade show that will be held in Birmingham, England, next May. Romano was honored for his four-decade career as a printing educator and researcher. He has served as editor of the International Paper *Pocket Pal* and the the *Encyclopedia of Graphic Communications*. Previous Champions of Print include *Harry Potter* author J.K. Rowling.

John Stratton, professor emeritus of electrical engineering technology, was the recipient of the American Society for Engineering Education's James H. McGraw Award in 2009. It is given annually for distinguished service and educational excellence in engineering technology. During his 37 years at RIT, Stratton was the chairperson of the electrical engineering technology department and associate dean of the College of Applied Science and Technology. He serves as an ASEE representative to the Technology Accreditation Commission, which oversees engineering technology education programs in American universities.

Thomas Smith, professor of chemistry and director of the Imaging Materials Laboratory in the College of Science, has been named an inaugural fellow of the American Chemical Society. Smith was

recognized for his broad ranging research in polymer chemistry, nanomaterials, and electronic materials; and for his service to the society on national and local levels throughout his 40-year career. The American Chemical Society was founded in 1876 and is the largest scientific association in the world.

The Center for Integrated Manufacturing Studies, a unit of RIT's Golisano Institute for Sustainability, received the 2009 Excellence in Economic Development Award in the category of University-Led Strategies, given by the U.S. Department of Commerce's Economic Development Administration. The center was selected for its numerous programs designed to enhance the development of new technologies in the manufacturing, alternative-energy, and environmental development sectors. CIMS was the only winner selected nationally in this category for 2009 and the first New York state winner among all categories since the awards program was established in 2004.

Andres Carrano and **Brian Thorn**, both associate professors of industrial engineering, won the 2009 Innovations in Curriculum Award from the Institute of Industrial Engineers. The award is given to a college or university engineering program that integrates creative instruction with relevant topics to meet the changing needs of the industrial engineering profession. Carrano and Thorn received the honor for their efforts to incorporate sustainability initiatives into RIT's industrial engineering program, which has resulted in the development of multiple sustainability focused courses, an undergraduate minor in sustainability, and two graduate degree programs in sustainable engineering.

The RIT Formula Race Car Team, advised by **Allen Nye**, professor of mechanical engineering, took first place in the Society of Automotive Engineers' 2009 Collegiate Design Series, California. The event featured 81 teams from colleges around the world who were required to design and build a formula race car and then compete in a series of performance challenges that tested speed, endurance, and acceleration. Nye has served as faculty adviser for the formula team for 17 years and it competes annually in a series of competitions in the U.S., Germany, and Australia.

Alan Singer, professor of art in the College of Imaging Arts and Sciences, was selected to participate in the 17th annual juried exhibition of the Bowery Gallery of New York City in 2009. Singer's works have been featured in numerous solo and group shows as well as exhibitions at the Smithsonian. The Bowery Gallery is one of the oldest independent galleries in New York and its juried show features top artists and students from all over the world.

About This Section

This listing is a sample of awards and honors that have been received by RIT faculty and staff over the past year. For more information, please visit www.rit.edu/news.

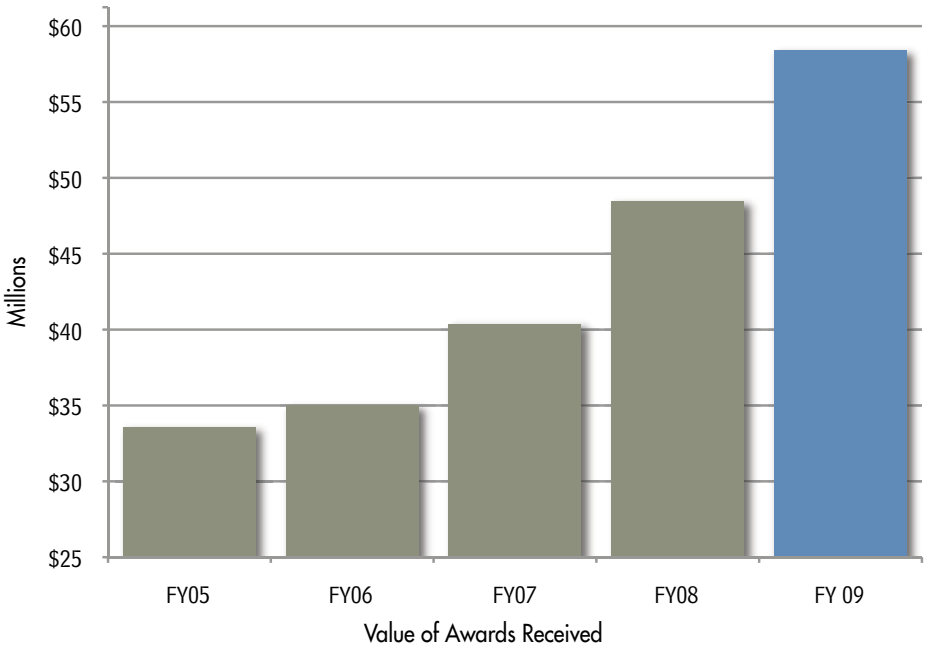
Financials

by Kara Teske

In FY 2009, RIT's research funding increased nearly 20 percent over the previous year, helping to expand research programs in three key areas: Imaging, Sustainability, and Bio-X.

For the fiscal year ending June 30, 2009, RIT received $58.4 million in new research awards. This growth reflects the continued efforts of a growing body of principal investigators and the support of numerous faculty and staff at RIT. In the past five years, the number of individuals writing research proposals has increased by nearly 30 percent, while the number of proposals has grown by 50 percent.

RIT continues to grow research in three key areas—Imaging, Sustainability, and Bio-X—along with a rich and diverse set of other areas.



Imaging

RIT researchers lead the world in Imaging, including a spectrum of expertise from astronomy, space science, color science, remote sensing, printing, image preservation, and more. The Digital Imaging and Remote Sensing Laboratory received $3.0 million in funding for research dedicated to the development and implementation of remote sensing tools.

The Printing Applications Laboratory (PAL) provides industry with practical, measurable information to control and improve the quality of their products. In 2009, PAL received $2.3 million for industry evaluation services.

RIT's Rochester Imaging Detector Laboratory, led by Dr. Donald Figer, received $556,000 from the Gordon and Betty Moore Foundation and $861,000 from NASA for the development of next-generation imaging detectors. Both are annual increments of larger multiyear awards.

Bio-X

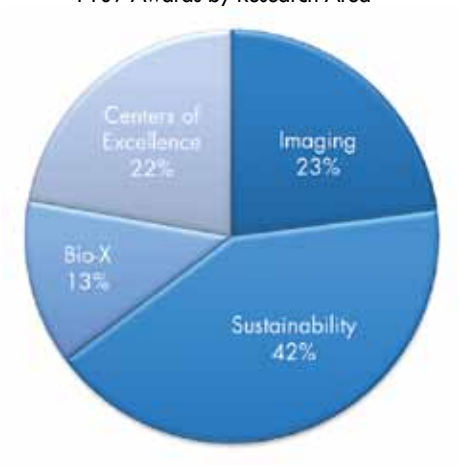
RIT researchers are also applying technical strengths to problems addressing biological, health care, and medical challenges—efforts collectively called Bio-X. These include growing bodies of research in the fundamentals of the cardiovascular and respiratory systems, biomedical device development, imaging applications, and basic research in biological sciences.

The National Institutes of Health made significant investments in RIT's biomedical engineering research, including support for the development of microtechnologies for inner ear drug delivery led by Dr. David Borkholder; and the development of a magnetically levitated left ventricular assist device, led by Dr. Steven Day.

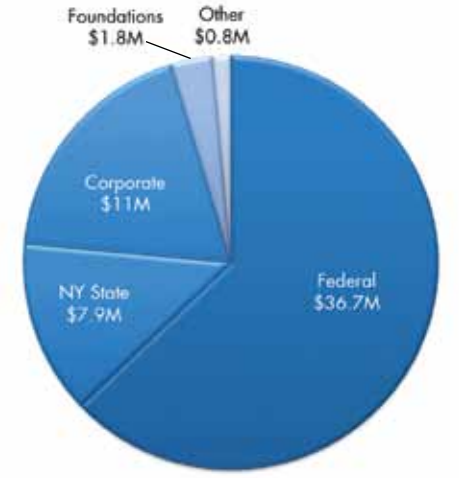
The recently formed strategic alliance with Rochester General Health System has also created new opportunities in the biotechnology field. Other new collaborations with industry partners, such as Ortho Clinical Diagnostics (a subsidiary of Johnson & Johnson), CareStream Health, and Blue Highway have also helped to expand Bio-X research at RIT.

Researchers at RIT's National Technical Institute for the Deaf continue to

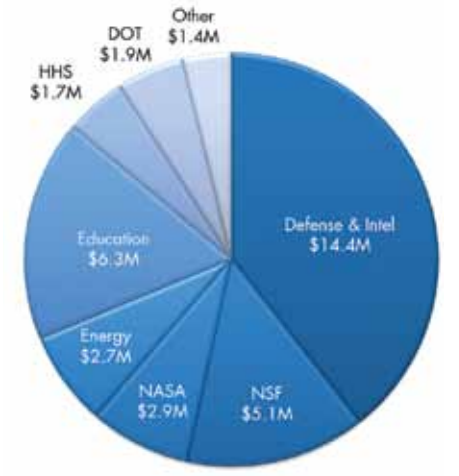
FY09 Awards by Research Area



FY09 Awards by Funding Source Type



FY09 Awards from Federal Sponsors



conduct research related to deafness and hearing, including deaf education and the development of assistive technologies. This year, NTID received $5.1 million in support of deafness and hearing research. In total, RIT received $7.5 million in funding related to Bio-X research.

Sustainability

RIT is also working to address the global challenges of Sustainability through interdisciplinary research efforts in sustainable production, alternative fuels, energy systems, and other integrated approaches.

The New York State Energy Research and Development Authority made several significant awards to RIT this year, totaling $4.1 million. This funding includes:

- Support for the RIT Clean Energy Incubator, an effort to help early stage renewable and clean energy technology companies overcome barriers to entry into the market through business and technical assistance. This project is a collaborative effort between RIT Venture Creations and the Golisano Institute for Sustainability.

- The Rochester Regional Clean Energy Education Partnership, an award to RIT and Monroe Community College to design courses in clean energy for classroom and online delivery. This project involves faculty in the College of Science and the College of Applied Science and Technology and is led by Dr. James Myers.

- Support for "Lean Energy and Environment" tools to demonstrate new technologies with increased energy efficiency for New York state's manufacturing companies. This is a large effort involving multiple RIT personnel led by Dr. Nabil Nasr.

Centers of Excellence

Other centers of research excellence—in microsystems, learning technologies, computer gaming, and many more—are part of the fabric of RIT. These areas have received $12.9 million in funding.

Funding Sources

RIT's research is supported by a variety of organizations, both public and private. In FY09, RIT received research awards totaling $7.9 million from New York state, $11 million from corporations, and $1.8 million from foundations.

Federal Sponsors

The largest sponsor of research at RIT is the federal government, which accounted for $36.7 million of awards received in the last fiscal year. Agencies within the defense and intelligence community funded new awards worth $14.5 million collectively. One of the largest sponsors is the U.S. Department of Education, with $6.4 million. Most of this supported research efforts at NTID, although the department also supports other efforts, including an award to upgrade emergency management planning for the RIT campus.

R·I·T

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Rochester Institute of Technology
RIT is one of the largest private universities in the world. With a unique blend of rigor and imagination, of specialization and perspective, of intellect and practice, RIT is a vibrant community of ambitious and creative students from more than 95 countries.

Rochester Institute of Technology is internationally recognized for academic leadership in computing, engineering, imaging technology, and fine and applied arts, in addition to unparalleled support services for students with hearing loss. Nearly 17,000 full- and part-time students are enrolled in more than 200 career-oriented and professional programs at RIT, and its cooperative education program is one of the oldest and largest in the nation.

For two decades, *U.S. News & World Report* has ranked RIT among the nation's leading comprehensive universities. RIT is featured in *The Princeton Review*'s 2009 edition of *The Best 368 Colleges* and in *Barron's Best Buys in Education. The Chronicle of Higher Education* recognizes RIT as a "Great College to Work For."

Contact Information

We conduct research to advance the body of knowledge, enhance student and faculty learning, and build our reputation in the scientific and technical communities while providing positive returns to our sponsoring partners. Please send your feedback directly or through the RIT research website at **www.rit.edu/research**.

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