SPECTRVM

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE FUTURE IS CITIES
CITIES OF THE FUTURE

WINTER 2014

Courtesy Höweler and Yoon Architecture

WINTER 2014

THE MIT SPECTRVM
is a newsletter distributed without charge to friends and supporters of the Massachusetts Institute of Technology by MIT's Office of Resource Development.

on the cover
Rotating between asphalt, grass, and photovoltaic cells, spaces can dynamically shift from city street to park to energy source – on demand. Roads cover 4.8 square miles of Manhattan, nearly four times the size of Central Park. If roads were solar panels, they could power 23.2% of Manhattan households.
http://vimeo.com/50787670
Courtesy Höweler and Yoon Architecture

THE FUTURE IS CITIES

If MIT aims to help invent the future, we have to think hard about cities. For the first time, cities constitute our species' dominant habitat. Now home to more than half of all human beings, cities have become the central stage on which our shared future will unfold. In that context, finding ways to seize the opportunities cities generate and to solve the problems they suffer becomes an urgent assignment.

As this issue of *SPECTRVM* makes clear, cities are already focal points for many of today's most important global challenges: Poverty. Human health. Water and food. Energy. Transportation. Environmental degradation and climate change. Innovation, the digital economy, and economic growth. And as humanity becomes more city-centered, cities are undergoing their own transformation, growing less centralized, more complex, and much, much bigger.

For all these reasons, we believe cities present important opportunities for MIT to apply its interdisciplinary creativity and hands-on problem solving to help invent a sustainable society.

We begin from our core strength in urban planning and architecture, magnified and extended by our expertise in a distinctive range of connected fields. For instance, cities are unending sources of data and impressive examples of interconnected systems; this creates rich opportunities to apply MIT's capabilities in sensors, big data, and systems thinking. Cities represent the primary source of demand for concrete, the root of 5–10% of the world's CO_2 emissions—which makes them ideal settings for nanoscience approaches to "greener" forms of concrete. And because cities are disproportionately coastal, they suffer outsized impacts from rising sea levels—and they stand to benefit most from new engineering, science, and policy ideas in response.

At MIT, we know how to listen to cities, how to read them—and how to act on what we learn. With the recent launch of our Center for Advanced Urbanism, we are seeking to reinvent them for the future, applying our cross-disciplinary strengths to help create cities that are cleaner, healthier, "smarter," more innovative, more prosperous, more resilient, and more livable.

We have never seen anything like the vast cities of tomorrow; they represent the frontier of human experience, and managing their growth will require the very best thinking from our faculty, students, and alumni around the world. There is no template and no textbook. In helping to shape tomorrow's cities, we are truly "learning by doing"—a perfect assignment for MIT.

Sincerely,

L. Rafael Reif

Phone (617) 253-3834
Spectrvm Online spectrvm.mit.edu
Email spectrum@mit.edu
Giving Online http://giving.mit.edu/

This paper is made with 30% post-consumer waste and responsibly managed sources

Vice President for Resource Development Jeffrey L. Newton
Executive Director of Communications David J. Gibson
Executive Editor Liz Karagianis
Contributing Writers Laurie Everett, Deborah Halber, Kathryn M. O'Neill, Eric Smalley, Elizabeth Thomson, Leda Zimmerman
Communications Assistant Jason Ruback
Design Yellow Inc.
Copy Editor Evanthia Malliris
Photography Richard Howard, Len Rubenstein
Cover Höweler and Yoon Architecture

T H E   F U T U R E   I S   C I T I E S

Cities around the world are growing faster than you can say megalopolis.

The Shareway, set for 2030. Imagine all transportation—trains, cars, bikes, and pedestrians—coexisting on a multilevel track to prevent traffic jams. Höweler and Yoon Architecture

More than half the world lives in cities, and by 2050, it will be two-thirds. In China alone, 300 million people will move to the city within the next 15 years, and to serve them, China must build the equivalent of the entire built infrastructure of the United States by 2028.

At the same time, 250 million new urban dwellers are expected in India and 380 million in Africa. Even though cities will soon account for 90 percent of population growth, 80 percent of global CO_2, and 75 percent of energy consumption, more and more, it's where people want to live.

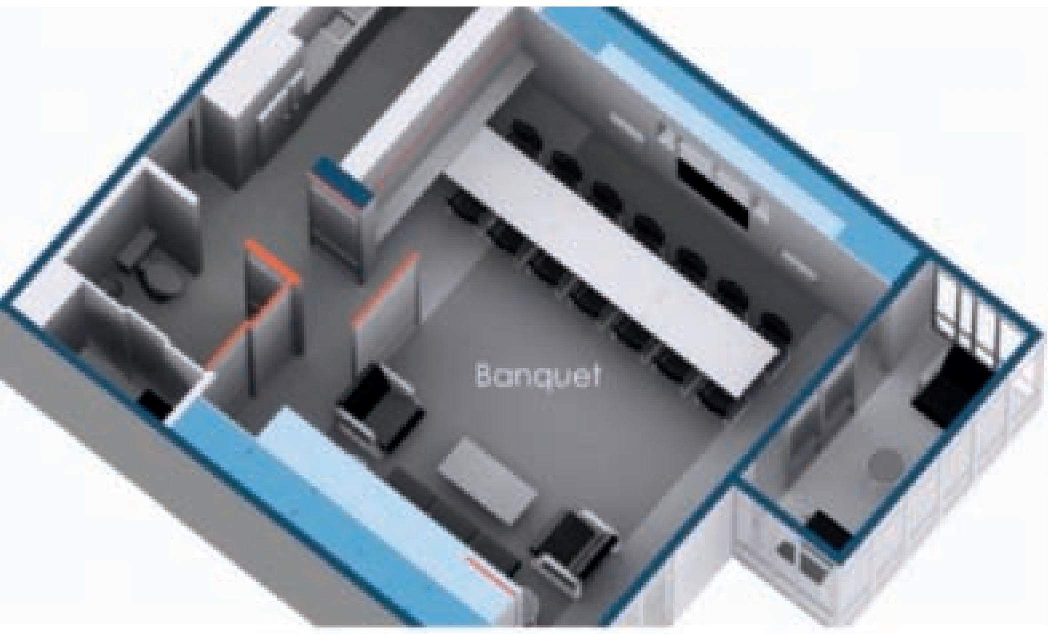
Why? Because it's where 80 percent of the wealth is created, and it's where people find opportunities, especially women in the developing world. But beyond basic needs from housing to jobs, how do we enjoy the benefits of the city—like cafes, art galleries, restaurants, cultural facilities—without the traffic, crowding, crime, pollution, and disease?

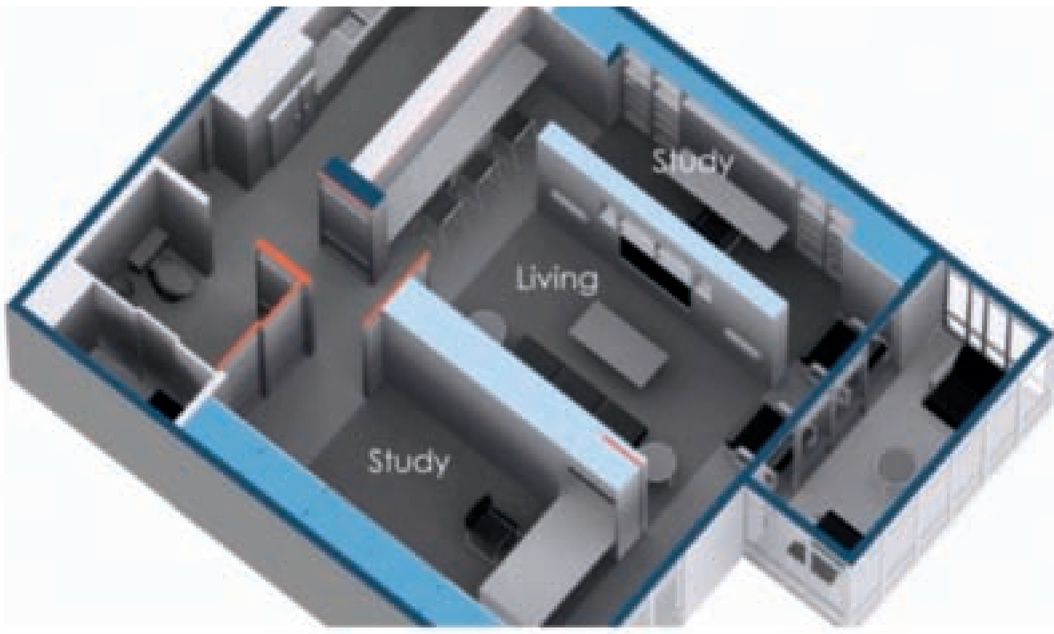
Dozens of MIT faculty are now working to figure it out, and there is no easy fix. The problems, they say, never end—poverty, affordable housing, clean water, transportation, congestion, garbage. And as if that weren't enough to keep an urban planner busy for life, the entire society, they say, is also now undergoing a worldwide paradigm shift—thanks to mobile communications and the Internet, global climate change, and a struggling economy.

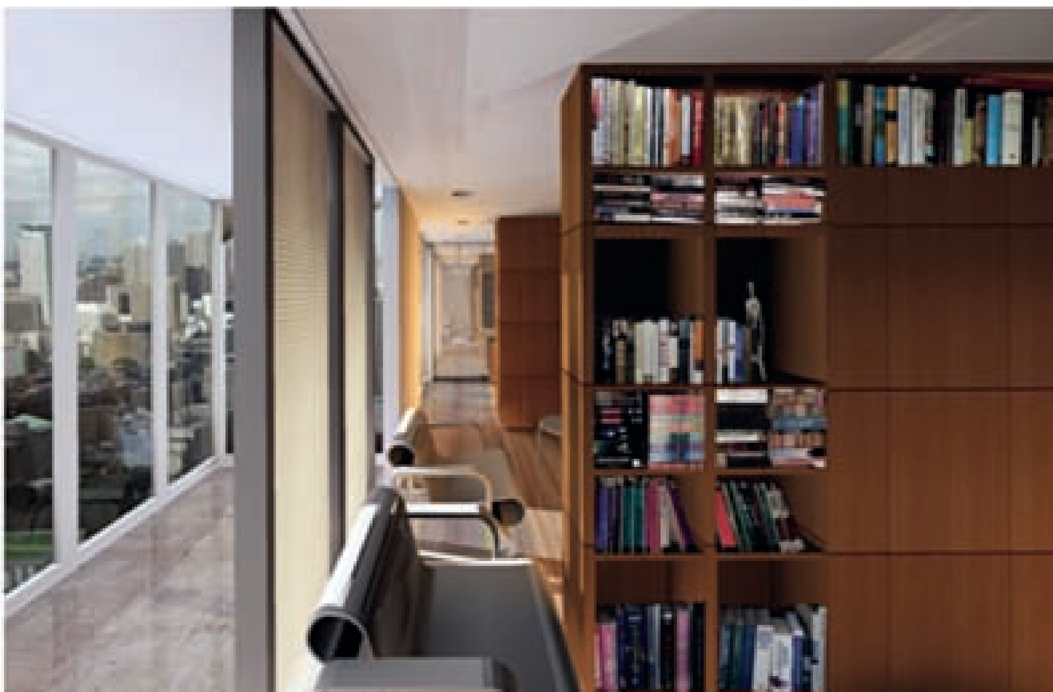
The shift is towards interdependence and sharing. Consider this:

The CityCar, zooming into the future: This stackable electric vehicle gets the equivalent of 200 miles per gallon and is designed to be shared. William Lark, Jr., MIT Media Lab, Smart Cities

Studio space: The average studio apartment will shrink to 300-square feet but will function at twice the size. Kent Larson, Changing Places group







"Privacy is Already Gone"

The American Dream is focused on ownership, and since World War II, Americans have wanted to own their own houses and cars because it signals success. But perhaps the American dream made more sense in the prosperous time after World War II than it does today.

The cost of houses and cars has become prohibitively expensive, and much of it has been bought on credit. Also, a warming planet and rising levels of CO_2 are causing more people to rethink driving and owning cars.

Faculty say what's beginning to matter to a growing number of Americans is not owning things. Thanks to the Internet and social media, climate change and a strained economy, a trend has emerged towards sharing. Consider, they say, house shares, car shares, bike shares, office shares, or farm shares.

"The younger generation is already sharing," says Prof. Eran Ben-Joseph, head of the Department of Urban Studies and Planning. "Young people are sharing cars, couches, and their whole personal life online.

"In the future, we'll see more sharing of personal items, like bikes and cars, not only in the U.S. but around the globe," adds Ben-Joseph, author of *Rethinking A Lot* (a book on parking lots), who says that with 600 million cars in the U.S., if all the surface lots were connected, it would cover land the size of Puerto Rico.

"A majority of people in China, India, and Brazil still live in tough conditions. And if they're slowly rising up, increasing their economic vitality, it's hard for them to hear our message not to invest in highways, cars, or personal goods," he says. "They shared their resources all their lives, and now with growing personal wealth also comes personal ownership. But to sustain the planet, eventually we all will have to change and learn to share our urban resources. Hopefully, they'll learn more quickly than we did."

Dennis Frenchman, Leventhal Professor of Urban Studies and Planning, adds: "The information age connected us, and now we can't go back to living our private little lives where everything belongs to only us. Our privacy is already gone."

Piggybacking, Boston to D.C.

In this spirit, Prof. J. Meejin Yoon, along with partner Eric Höweler, developed the Shareway, a bold new vision for sharing the road in 2030. The Shareway, which won the Audi Urban Futures Award in 2012, would merge all forms of transportation on the existing I-95 Boston to Washington corridor into a single artery, piggybacked by a new high-speed rail system.

Imagine all transportation – commuter and freight trains, cars, bikes, and pedestrians – coexisting on a multilevel track to prevent traffic jams. Tracing the 400-mile route from Boston to Washington, the "BosWash" Shareway would connect to a Superhub in Newark with an airport, seaport, rail station, and interstate intersection. Also part of the plan are house-sharing programs and converting vacant land in Baltimore into agricultural fields.

"We created this project to inform people and to entice them into thinking differently. We wanted them to think about, talk about, and imagine alternative possibilities in the future," says Yoon, adding that the sole intent of the bold design was to shift consciousness, expanding our minds to grasp a new reality.

Small is the New Big

Kent Larson has already grasped the new reality. He's director of the City Science Initiative at the MIT Media Lab, and his group is responsible for the CityCar, which is zooming into the future at 30 mph. Designed to be shared, this stackable electric vehicle gets the equivalent of 200 miles per gallon and folds for parking to one-third the size of a regular car.

And as more people crowd into cities, the average studio apartment will shrink to 300-square feet, says Larson, whose group is also designing micro apartments to function at twice the size.

"You can effortlessly convert a two-bedroom apartment to a party space. The bed and table lift up to the ceiling, the walls move, and you've got one big open space in a matter of seconds," he says, adding that small tables pop up, furniture folds out of walls, or sinks sit like shelves over the toilet. Quick-change apartments are a big plus for residents who want a shorter commute, affordable housing, and city life right outside the door, he says.

Kent Larson: Part of the sharing trend is shared workspaces. Richard Howard

J. Meejin Yoon: Develops the Shareway for 2030 with Eric Höweler. Richard Howard

Dayna Cunningham: "You learn to make a way of no way." Richard Howard

Eran Ben-Joseph: In the U.S. alone, 600 million cars. Courtesy MIT News Office

Also part of a sharing trend is shared workspaces. Rather than leasing a separate office, hundreds of startups are renting coworking facilities in one building. "Instead of 100 companies buying equipment, they share. It's happening all over the world and the trend will just continue," Larson predicts.

"Breathtaking" Problems

Just as we share what is good and beneficial to our lives, we also share the problems—flooding, food distribution, rising levels of CO_2. "The problems are vast," says Adèle Santos, dean of the School of Architecture and Planning, adding for example: "You can't even breathe the air in China."

China is choked with traffic and pollution. But when that air from China blows east, it also accounts for 20 percent of the pollution on the U.S. west coast—and that's when just one-tenth of the Chinese own cars. What will the air be like when that number triples in the future?

"If you're going to solve the problems of future cities, you have to have an interdisciplinary call to service," says Santos, adding that old practices —like building sprawling, car-centric cities or building on arable land—no longer work. "Honestly, there are very few problems of this magnitude that can be solved by one discipline. The problems are huge. Breathtaking, actually. And it's scary, because you don't want to fail, and yet, it's incredibly complex. We're planning at a scale that's absolutely unprecedented, and effectively speaking, we don't really know how to do it. That's the truth."

That, she says, is precisely why this year the School launched the Center for Advanced Urbanism (CAU) — an interdisciplinary think tank that focuses on big-scale urban design problems, with 22 faculty labs collaborating on solutions.

Collective Energy

Prof. Alexander D'Hooghe, director of the Center for Advanced Urbanism, believes that MIT is a leader in cracking global problems precisely because of its expertise in crossing disciplines.

"When MIT began 150 years ago, it was by definition a model of integrating disciplines—chemical engineering, design, physics—were literally integrated into a mega structure, and it's the way we still operate today," he says. "Collaboration is built into MIT's genetic material. That's our destiny."

On one project, he adds, CAU is consulting with four faculty from different disciplines, on another, with nine at a time. Collaborating and sharing ideas with many is great for gleaning solutions, he says, but it also carries new challenges. "In a way, it's like being a negotiator in a foreign conflict," says D'Hooghe, a designer and civil engineer, adding that working with multiple people, and across multiple disciplines, requires deep empathy, careful listening, and great diplomacy.

Prof. Nader Tehrani, head of the Department of Architecture, agrees. "We're beginning to understand that we don't design cities on our own desks. We've become a consortium, where the architect becomes a mediator, an ambassador of different disciplines. We're now like conductors, maestros in the symphony," says Tehrani, who understands that when many pool their minds, something marvelous happens—their collective energy becomes a force that helps solve the problem.

A generous gift from the Sherry and Alan Leventhal Family Foundation is supporting the work of the CAU for the next three years.

Decade of Design

One problem under way at the Center for Advanced Urbanism focuses on how physical design can improve human health — such as obesity, asthma, cardiovascular disease, diabetes, or depression. Called the Decade of Design: Health and Urbanism Initiative, the 10-year project is a collaboration among MIT, the American Institute of Architects, and the Clinton Global Initiative.

The very field of urban planning was born out of concern for public health, D'Hooghe says. Industrial cities were overcrowded in the late 19th century, and urban planning was a response to the crisis. Frederick Law Olmsted, for example, designed New York's Central Park to give residents of a dirty, crowded city acres of grass for exercise and recreation. Similar is thinking of public health today.

Prof. Alan Berger, CAU's research director, says, "In Los Angeles, city planners and transportation planners have a 30-year vision to add denser housing near major highways with highly polluted air. It may reduce commuting a bit if jobs are also nearby, but not enough to significantly improve air

Dennis Frenchman: Working to stem pollution in China. Richard Howard

Alexander D'Hooghe: Collaboration is our destiny. Richard Howard

quality. What they overlooked is that adding more people would also likely lead to increased asthma rates or premature death, as scientists have since shown."

The Health and Urbanism study will help identify factors that contribute to urban health, since some design guidelines are not effective nor proven, Berger says, such as the belief that people get more exercise in cities with sidewalks or that higher diabetes rates correlate with higher numbers of fast food restaurants. "Every urban setting is unique. There are no silver bullets."

Dynamic breakthroughs in urban issues eventually will come not from one discipline or another, but from the dark zones of knowledge that lie between disciplines, he says, adding that if you work at it enough, from the darkness emerges light.

The CoLab View

Dayna Cunningham believes in shining light on everyone, because with big problems, solutions can only be holistic. "We consider people from different social positions as colleagues," says Cunningham, executive director of MIT's Community Innovators Lab (CoLab).

For example, poor people actually are experts on problems from illness to dealing to life without money, yet in a bad economy, no one asks them how they make ends meet, often because they've been told what they think doesn't matter. The Lab—now working with community organizations in the U.S., Latin America, and the Caribbean—co-develops projects with people at the margins of an urban system, from energy to economic development, "because they offer tremendous insight," she says, adding that the lab casts the poor not only as those with problems but as inventors of creative approaches.

"A whole range of judgments go with being poor, and if you have grown up marginalized, you have internalized that," says Cunningham, who is sensitive to those whose voice is unheard, and whose own African-American great uncle—who graduated from Yale Law School—worked as a Pullman Porter, carrying bags and serving whites on trains.

"We have people—from soccer moms to police chiefs to kids in hoodies—whose life experiences are counterintuitive, whose life truths are opposite, and we put them together around the table and get them to co-create solutions."

That, she believes, is how we will solve our problems. Another Smart car can't heal the planet, but what may, she says, is putting together people with different kinds of experience and intelligence and learning to co-create. "You learn to make a way of no way."

"It's Not Me, It's Us"

Our lives are connected. Think of fallout from Fukushima, indifferent to boundaries that divide countries. A downturn in one economy affects other economies. An oil spill in the Gulf of Mexico reverberates around the world.

The world is one. Our destiny is linked. How we survive depends on how we cooperate.

"It's all global," says Dennis Frenchman, who is working to stem pollution in China. "Digital technology has put a nervous system into the planet, so we can actually feel the pain in China. This is a global level of consciousness and interdependence that we just never had before."

The shifts caused by climate change, the economy, and social media, Frenchman says, bring a new reality. "The old ways are collapsing. All these changes are interrelated, and because of the Internet, we have a different notion of privacy than our parents did. It's becoming an inclusionary society. We are seeing small changes, then all of a sudden they will accumulate, and we're going to see a whole new city. You may not be aware of it, but you're living it."

J. Meejin Yoon says perhaps these changes will also change us. If the American Dream of ownership made us greedy or competitive, perhaps a sharing society will make us more generous or caring.

"I think it will," she says. "You need to be more generous and tolerant when you live in a city. When you compress people together, you need to be OK with noise upstairs or when a neighbor leaves a bike in the stairway.

"The biggest message of this shift in consciousness is—it's not me, it's us," she says. "We have a sense we're in this together, that the challenges surpass each individual.

"We have to work together," she says, "otherwise not only will our cities fail but we will all fail as well." ~ LIZ KARAGIANIS

Chris Pfaff — Susanne Seitinger
iSoftstone — Tianwen Liu
Leslie Cashen — Tim Campbell
Helmut Lotze — Helmut Lotze
Benjamin Brook — Patricia McCarney
Stuart Darsch — Fred Salvucci

In Stuttgart, Germany, the new solar-powered train station: Eight underground tracks will connect to a high-speed rail network. Courtesy: Holger Knauf, ingenhoven architects

SHAPING VIBRANT CITIES

Alumni Meet Across the World to Discuss Urbanism

From Abu Dhabi to Zurich, MIT graduates are converging to talk about the welfare and future of cities. "I've been involved in the topic for more than 40 years, waving the flag and saying the planet's going urban," said Tim Campbell PhD '80, author of *Beyond Smart Cities* (Routledge 2012). "In the last couple of years, that corner's been turned. There are lots more meetings being held, and everyone's asking the urban question."

Campbell is chairman of the Urban Age Institute, which is dedicated to building alliances among leaders and innovators in the areas of technology and urban sustainability. At its annual Meeting of the Minds conference, held last September in Toronto, "there were tons of MIT people," said Campbell.

One of them was Patricia McCarney, PhD '87, professor at the University of Toronto, and director of the new Global Cities Institute (GCI). McCarney has built a global network of more than 250 cities across 80 countries within her Global City Indicators Facility, a comprehensive database of vital urban data, giving cities the tools to learn from each other. GCI launched a series of reports drawing on this database with a study outlining strategies for addressing a rapidly aging urban population. "Urban design models that integrate seniors into walkable, mixed-use areas are the hallmarks of a healthy city," said McCarney.

Another Toronto participant, Fred Salvucci, '61 SM '62, the former secretary of transportation for Massachusetts and current MIT Transit Lab research associate, discussed Boston's transportation megaproject, the Big Dig, over which he presided for more than a decade. "It's important to figure out how to do megaprojects better, because these kind of interventions are essential if we're to make cities greener, denser, and more transit-oriented, and if people are to function happily rather than miserably," he said.

In Europe, a flurry of conferences drew participants like Susanne Seitinger, MCP '04, SM '06, and PhD '10, who noted, "Wherever I go, I bump into a lot of MIT people." The city innovations manager at Philips Color Kinetics, Seitinger was scheduled to attend Futurapolis, in Toulouse, France. An MIT Media Lab graduate profoundly influenced by the late William Mitchell, former dean of the School of Architecture and Smart Cities guru, Seitinger's agenda included sharing her research on LED lighting that can both shrink cities' energy bills and be programmed to illuminate an urban environment "like a painting."

At a symposium hosted by the MIT Club of Germany last October, alumni gathered in Stuttgart to explore urban development and mobility. Invited speakers included Christian Marion MArch '87, a French urban planner and member of the MIT Club of France, who compared large infrastructure projects in France and Germany, and J. Meejin Yoon, associate professor in the Department of Architecture, who discussed integrating urban planning and mobility. "The exchange of new ideas and professional experiences is at the very beginning," stated Helmut Lotze MCP/MArch '94, and MIT Club of Germany board member. An architect and city planner in Dusseldorf, Lotze expressed the desire "to improve networking."

A few weeks later and half a world away, the MIT Industrial Liaison Program sponsored a conference in Beijing focusing on innovation and technologies to help with China's rapid and wrenching urbanization. One participant, Tianwen Liu, MBA and Sloan Fellow '96, noted that "many MIT alumni are now business leaders in various industries, and we all want to contribute to helping China succeed in the mega urbanization movement, including building sustainable and more livable future cities."

Liu, the chairman and CEO of Chinese IT giant iSoftstone, said he is working with the Chinese government to "introduce MIT technologies and best practices," including MIT executive education programs, in several cities. He hoped "that the mayors and officials involved in the urbanization projects will be exposed to the latest urban planning and city management know-how."

~ LEDA ZIMMERMAN

URBAN PHYSICS

Franz-Josef Ulm and a colleague were taking a break from a tough problem one afternoon when they spotted an aerial photograph of a city and suddenly had an epiphany. Instantly, they made a connection between the patterns of houses and streets and the underlying molecular structure of concrete.

That serendipitous observation has since led to research that is tying together the seemingly disparate disciplines of physics and urban planning. "Ultimately, I believe there's potential for this to become a new field of study. It also could lead to new tools for architects and city planners," says Ulm, the George Macomber Professor in the Department of Civil and Environmental Engineering, and co-director with Senior Research Scientist Roland Pellenq of the International Joint Unit (UMI) between MIT and CNRS, France's National Center for Scientific Research.

Urban physics, as Ulm calls the new work, views cities as analogous to complex materials. Over the last 50 years, physicists have developed ever-better statistical tools to learn more about materials at the molecular scale. And Ulm himself is a world leader in using them to understand the structure of concrete with the ultimate goal of creating better versions of the material.

Ulm and colleagues are now modifying these tools to explain cities. "Essentially we take a big city and compress it, extracting only the most important statistical information," says Ulm. The end result is computer models that can accurately capture the internal structure of a city with a minimum of data. These models can then be manipulated to explore how a city will respond to phenomena from the intense winds of a hurricane to the higher temperatures associated with global warming.

Just as atoms in a molecule arrange themselves in repetitive structures, researchers have discovered that buildings in a city have an order that when repeated on a macro scale gives cities distinct properties. This local order can be computed from physics models that, in turn, incorporate available Geographic Information System (GIS) data, such as the heights of buildings and the distance between them.

So far, the researchers have analyzed 12 cities in the United States. They've found that each has a distinctly different structure that, following the molecular analogy, can range from being a highly ordered crystal (New York) to a less-ordered glass (Chicago) to an amorphous liquid (Boston).

Those structures, in turn, determine how a city will likely respond to different stresses. For example, the MIT team has found that cities with a crystal structure absorb and retain more heat than those with less ordered structures. That particular finding could help urban planners better understand—and mitigate—different cities' responses to global warming.

Initially, other physicists were skeptical of the work, Ulm recalls. "They said, 'You crazy guys, you're jumping twelve orders of magnitude from one field [molecular physics] to another [urban planning].'" But "as we move forward, we're finding city patterns that are amazing, and we really believe they could have a major impact for 21st-century urban planners."

~ ELIZABETH THOMSON

Franz-Josef Ulm: Spotting this aerial photo of a city, he made a connection between the patterns of houses and streets and the underlying molecular structure of concrete. Len Rubenstein

Skylar Tibbits's fluid crystallization project: Self-assembly holds the promise of breakthroughs in many fields. Len Rubenstein

SMART COMPONENTS, ASSEMBLING THEMSELVES

Skylar Tibbits was constructing a massive museum installation with thousands of pieces. "Imagine yourself facing months on end assembling this thing, thinking there's got to be a better way." A designer and architect, Tibbits was accustomed to modeling and fabricating his complex, architecturally sophisticated sculptures with computation. It suddenly struck him: "With all this information that was used to design the structure and communicate with fabrication machines, there's got to be a way these parts can build themselves."

This epiphany propelled Tibbits to MIT for dual master's degrees in computer science, and design and computation, in pursuit of the idea, says Tibbits, "that you could program everything from bits, to atoms, and even large-scale structures."

Today, Tibbits is breathing life into this vision. A research scientist in the Department of Architecture, and a TED2012 Senior Fellow, Tibbits has launched the Self Assembly Lab, where like-minded engineers, scientists, designers, and architects respond to real-world challenges from industry partners to transform commonplace materials into responsive and reconfigurable building elements, ones that can coalesce on their own to form precise structures. Deploying such novel techniques as 4-D printing in collaboration with Stratasys, a firm at the forefront of three-dimensional modeling, Tibbits is experimenting with new products and processes from the nano- to the human scale.

Although still in its infancy, Tibbits's research might someday make a profound impact on the built environment. One project, called Logic Matter, encodes simple decision-making in a material, using only that substance's properties, shape, and geometry. Bricks could be programmed to analyze their own loading conditions or orientation and might contain blueprints to build a wall or guide someone in the construction process. "We don't have to change what we build with," says Tibbits. "We take seemingly dumb materials and make them more responsive by combining them in elegant ways with geometry and activation energy."

Natural processes such as the replication of DNA, protein folding, and the growth of geometrically perfect crystals inspired Tibbits. He discerned that these systems, which build complex structures extremely efficiently, and which can replicate and repair themselves, depend on a common formula: a simple sequence of instructions, programmable parts, energy, and some type of error correction. Mastering this recipe opens up a world of useful applications, believes Tibbits.

One illustrative project underway in Tibbits's lab may lead to more resilient and efficient infrastructure. He is trying to program peristalsis in water pipes, so they contract and relax like muscles. Unlike current pipes, which tend to break, require constant monitoring and energy input, Tibbits's pipes can expand and shrink in response to changes in water volume, and could eventually undulate to abet flow. The goal is a "self-regulating system," one in which pipes could even repair themselves in case of a puncture.

Self-assembling technologies may eventually help build space structures whose components deposit themselves in zero gravity environments without human intervention, and edifices that become more resilient in response to "noisy and potentially dangerous energies" from phenomena like earthquakes, hurricanes, and tsunamis. These ideas may seem like a reach, but "there are structures we can't build today," says Tibbits, which demand new approaches. "We must ask where self-assembly can solve some of the world's biggest challenges."

~ LEDA ZIMMERMAN

WHERE ECONOMY MEETS ECOLOGY

Think of a city as a complex organism powered by human activities and consumption. John E. Fernández, associate professor in the Department of Architecture, wants to understand how the urban metabolism works – what it needs in terms of energy, materials, and water to sustain the work and lives of its residents, and what gets discarded as waste. "When we speak of a healthy city," says Fernández, "we are really focusing on whether it strikes a balance between economic growth and resource efficiency."

Fernández is at the forefront of an emerging science of urban sustainability that explores the interplay between a city's economy, increasingly tied into global networks, and its ecological consequences. With 3.5 billion people living in cities today, another 3 billion on the way, and the onset of climate change, urban designers are looking for successful models to accommodate humane and sustainable growth. Director of MIT's Building Technology Program and leading the Urban Metabolism Group, Fernández has been immersed in several ventures that may bring such models closer to reality, by providing a framework for analyzing and enhancing urban sustainability.

One initiative identifies the types and volume of resources consumed in urban environments. "A city acquires and transforms diverse resources for its own metabolism. We literally do a physical accounting of materials and energy required by an urban economy," says Fernández. This means measuring the millions of gallons of water used for drinking, power, and waste; kilocalories of fossil and other fuels consumed by residents, construction, and other industries; and tonnage of raw materials and goods entering a city. It also means calculating end products of human activity such as waste water and CO_2 emissions. So far, Fernández has conducted urban metabolism assessments of cities across the world.

"In the 1st century B.C.E., the Roman engineer Vitruvius laid out cities to take advantage of healthy wind flow, and he had it right to emphasize the relationship between the form of the city and its immediate environment," says Fernández. A few millennia later, the Urban Metabolism Group has produced a way of visualizing the relationship between city form and resource consumption in 40 U.S. cities. This online tool (urbmet.org) analyzes data to give users a picture of resource and energy intensity at scales that vary from entire metro areas to specific neighborhoods.

Fernández notes that differences in resource usage among cities can be attributed to historical and technological factors, income and other measures of affluence, climate and location, and population size and density. Yet in spite of great variations among cities, all urban economies provide housing for people and firms, transportation, and critical goods and services. After examining similarities and differences among dozens of cities, Fernández and his students have developed a global urban typology based on resource consumption. With an analysis measuring per capita material impact and socioeconomic characteristics, they have defined eight city types, revealing some provocative groupings:

Moscow, Santiago, Seoul, and Honolulu, which share medium-sized populations, city densities, and trade levels, fall into one group. Anchorage, Stockholm, and Abu Dhabi, dependent on oil production and intense consumers of resources, define another cluster. The Japanese cities studied constitute a group all their own, with low energy and biomass use, large populations, and small geographic areas.

Fernández hopes his research will help urban planners seeking methods for lowering resource consumption and accommodating growth. One possibility for cities to capture enormous energy savings, offers Fernández, involves developing walkable districts of much greater population density in supertall, high-performance buildings. "Civic life can move up," he suggests. "The global race to find pathways to urban sustainability has begun, and I hope to provide cities with the solid scientific foundation for understanding how to design and manage these transitions."

~ LEDA ZIMMERMAN

John Fernández: At the forefront of urban sustainability, an emerging field that explores a city's economy and ecology. Len Rubenstein

BARRIERS TO OPPORTUNITY

How much does your neighborhood determine your life chances? Sociologist and urban planner Xavier de Souza Briggs recently completed a 20-year social experiment on ghetto poverty that asked: If people in high-poverty, high-risk areas of the inner city moved to low-poverty areas, would their lives change for the better? The findings revealed that many study participants "successfully" escaped dangerous and stressful neighborhoods at first, most did not escape income poverty, and many ended up living back in high-poverty areas after a few years. Briggs and his collaborators wanted to know why.

The experiment was conducted in 5 US metro areas: greater Baltimore, Boston, Chicago, Los Angeles, and New York. While the experiment showed it was possible to dramatically improve the quality of life of the poor, helping them escape poverty was another matter. "Many of us underestimated the barriers to employment, for example, for this highly disadvantaged group, and how small a difference relocation alone would make," says Briggs, an associate professor.

"Severely disadvantaged people are often information-poor, lacking job networks and networking skills. For one thing, they lack essential information about which job training opportunities are most likely to pay off. People throughout America, especially the poor, are constantly marketed to with ads that promise jobs that won't exist for them."

Low-income families face other complex challenges as well. "When people are juggling on the bottom of the ladder, they don't need access to just a job. They need an affordable apartment and affordable childcare. Most of these families are headed by single moms, who are at much greater risk of persistent poverty, than other types of households," he says of the findings detailed in his book, *Moving to Opportunity: The Story of an American Experiment to Fight Ghetto Poverty*.

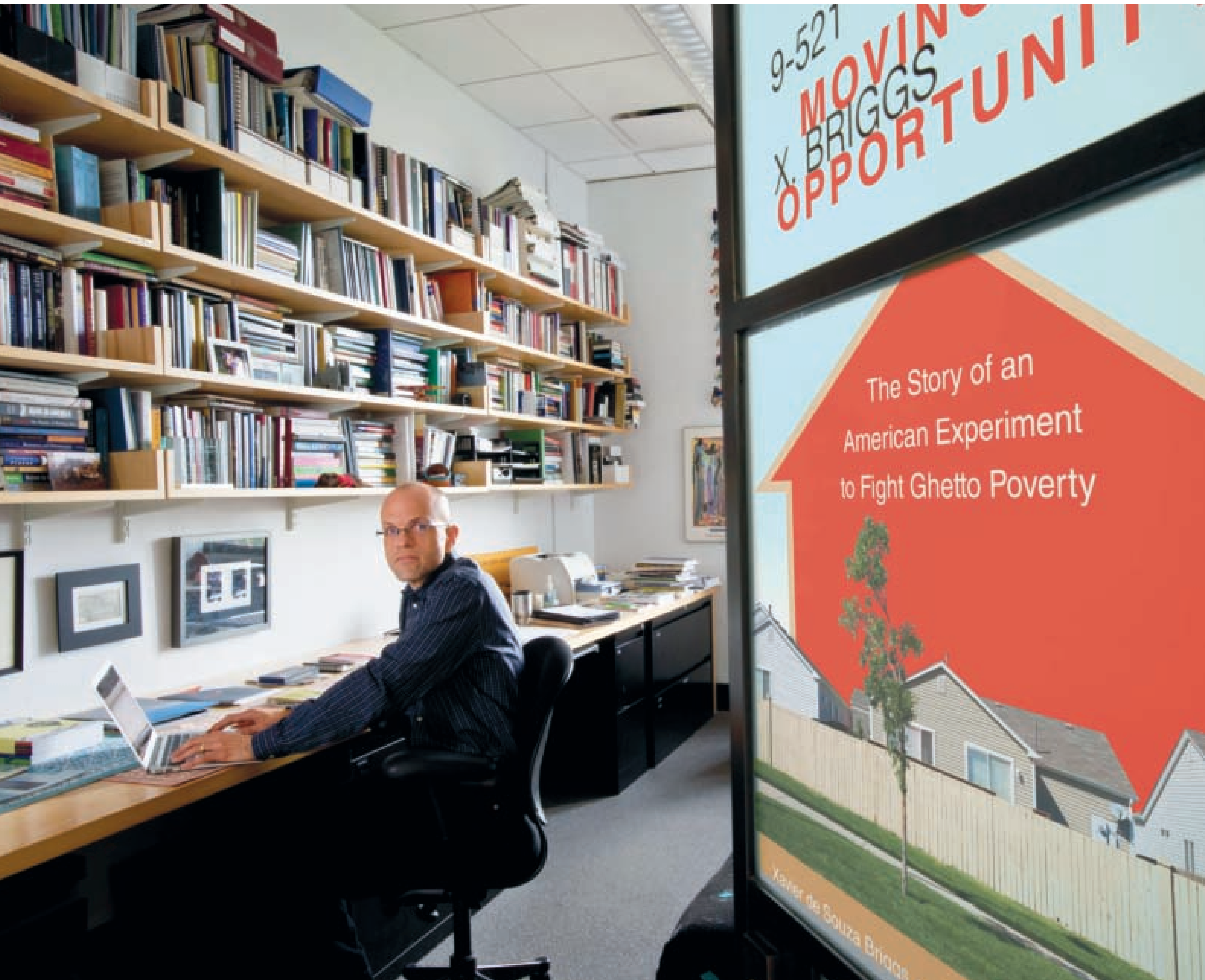
The barriers were the greatest in sprawling Los Angeles, he says. "The physical distances are so enormous, and many jobs are not accessible by public transportation. We spent time with moms who were getting up at four a.m. and driving 25 miles in one direction to leave their kids with a family member, and then 30 miles in another direction to work at a job where they might be put on a different shift, on a moment's notice. The job itself was insecure, volatile, and poorly compensated. Lining up housing, work, and childcare and keeping them aligned—was immensely difficult."

On the upside were dramatic changes in safety and security, particularly for young girls. They fared better overall in these new neighborhoods, escaping the predatory climate of their old neighborhoods. And parents in the study saw major reductions in anxiety, depression, and improvements in mental health, likely because of increased security and "freedom from fear."

"I would love to have seen impacts on economic opportunity," reflects Briggs. "We thought that moving might affect access to useful networks of people who were employed and had better information, or that being physically closer to certain kinds of jobs might make a difference. But as it turned out, those changes did not develop. And what's more, the families' footholds in safer areas were insecure, because of the scarcity of affordable rental housing in these markets."

~ LAURIE EVERETT

Xavier de Souza Briggs's 20-year study: If people in high-poverty areas move to low-poverty areas, soon they may be no better off. Len Rubenstein



RESILIENT PLACES

San Francisco was nearly wiped off the map by earthquake and fire in 1906, yet residents seized on the disaster as an opportunity to rebuild and expand. Warsaw lost 85 percent of all its structures in World War II, but today it is Poland's largest city. Even nuclear devastation could not eradicate Hiroshima; the city regained its prewar population in just 10 years.

What explains such remarkable resilience?

According to Lawrence J. Vale, MIT's Ford Professor of Urban Design and Planning, it's a testament both to human will and to the extraordinary attachment people have to places. Although computers and teleconferencing make it easier than ever to live and work apart, people continue to be drawn to cities for the unparalleled opportunities they provide for face-to-face interaction and commerce. "It's an affirmation of just how much people want to be with other people," Vale says.

Rebuilding devastated or blighted cities, therefore, is not so much a technical or physical challenge as a deeply human endeavor driven by the will to overcome adversity. "You think you have a technical design problem to solve, but what you have is a window into conflicting human values," Vale says.

This distinction is one that urban planners have sometimes failed to recognize. The notorious urban renewal efforts of the 1950s, for example, wiped out dense ethnic neighborhoods such as Boston's West End in favor of streetless "superblocks" and gleaming high rises. "There was a decision to reject the historic form of the city as overcrowded, obsolete, and dangerous and to reject the kinds of communities that had been built over time in those places," Vale says. Such projects proved catastrophic for city residents who couldn't afford to return to upgraded districts; they also produced whole areas inhospitable to the human interactions that make cities vibrant. Urban renewal was deemed a failure.

In contrast, good urban planning can quite literally save lives. When a 7.0-magnitude earthquake struck Haiti in 2010, Port-au-Prince was practically leveled; hundreds of thousands of people died. Yet, when an 8.8-magnitude earthquake hit near Concepción, Chile, less than two months later, just 525 people were killed. One major reason for the disparity, Vale says, is that Chile enforced strict building codes to ensure more structures were earthquake-resistant and Haiti did not.

Unfortunately, building better structures can be expensive and, as Vale says, "You can't just say Haiti should be less poor." That's why urban planners at MIT are looking for ways to protect vulnerable populations cost-effectively—a key goal of the Resilient Cities Housing Initiative, which Vale launched this spring.

MIT researchers will investigate how best to house a city's least advantaged residents in a world facing increasingly extreme weather conditions due to climate change. And, they will take on a challenge fundamental to all modern city planning: how to motivate people to prepare for the next disaster.

What makes cities so resilient after disaster? Larry Vale with post-Katrina New Orleans. Len Rubenstein

"How do you get people to think, as they did in the Netherlands in 1953, that they need to plan for a so-called 10,000-year flood that may—or may not—come soon?" Vale asks. The answer remains elusive. "It's hard to sell until something happens."

~ KATHRYN M. O'NEILL

SEDUCTIVE SPACES, SUSTAINABLE ENERGY

Christoph Reinhart: A new modeling system to evaluate hundreds of buildings at a time. Len Rubenstein

The average pedestrian meandering through urban spaces such as Manhattan's Washington Square Park or San Francisco's Embarcadero isn't calculating the ratio of vertical to horizontal building surfaces or the percentage of tree coverage. But MIT building scientist Christoph F. Reinhart is, with an eye to creating seductive city spaces that also support sustainable energy.

Over the next two decades, the United Nations expects an additional 1.7 billion people to converge in the world's cities. With buildings already accounting for some 40 percent of carbon emissions in many countries, Reinhart, associate professor of architecture, believes there's an undeniable need for sustainable urban growth that works across climates and cultures.

Reinhart, who leads MIT's Sustainable Design Lab, has created a new modeling system called umi (pronounced ooh-me), which, unlike existing tools that analyze an individual building's energy outlay, allows design teams to model and evaluate dozens or even hundreds of buildings at a time http://urbanmodellinginterface.ning.com/. He sees umi enabling city planners and architects — for the first time — to improve the performance of their designs at both building and street scales.

Reinhart grew up in Dusseldorf, became a physicist and studied and worked for a time in the beautiful university city of Freiburg, where he saw people getting around by walking, taking the tram, or cycling on plentiful bike routes. He decided to switch his focus from photovoltaics to architecture when he realized that architects and city planners propel a lot of the decisions that drive the construction of energy-efficient buildings and usable, sustainable urban spaces.

Cities such as Freiburg, New York, Paris, and Copenhagen cater to pedestrians, but "there are examples of how *not* to do it all over the world," Reinhart points out: urban spaces lacking trees, or shelter from heat, cold, and wind. Cities need comfortable open spaces, he says, where people simply feel inclined to spend time outside, as well as buildings that work with their local microclimate.

There are strategies for accomplishing this — solar cells, natural interior lighting, bike paths, for instance — but without metrics, policy makers don't know where to concentrate their efforts. "We want to work with cities to build umi models of their existing structure and use this for future policy decisions," Reinhart says. Umi currently has several models that allow users to estimate operational energy use of buildings, daylight availability throughout a city as well as how walkable a neighborhood is.

While umi is a more specialized simulation environment for urban planners and architects, Reinhart's group also collaborated with Mapdwell LLC to develop a "lightweight" version of umi, a solar map for Cambridge that helps residents identify which roofs are best suited for solar panels; how much the panels would cost; how much revenue they would generate; whether they could handle peak loads. Umi collects data that could help determine if people would walk to a planned shopping area or commute on a proposed bike path.

The model is already at work in Cambridge, Mass., where an umi solar map, accessible to the public through an interactive web site, http://en.mapdwell.com/solarsystem/cambridge, points out in vibrant yellows, reds, and blues the city's hot and cold spots — buildings that "leak" heat, blocks that tend to bake in the sun, or suffer arctic-like chill in winter.

"When you see that color heat map, it's very powerful," Reinhart says. "If you are the owner of a building that's red, it can trigger all kinds of discussion...and action." Fundamentally, urban modeling tools such as umi and the Cambridge solar map are to provide visual, easy-to-interpret tools that make it easy to talk intelligently about design and to help put buildings together so the result is more livable and more environmentally sustainable.

~ DEBORAH HALBER

A SOFT HOUSE TO LAST A CENTURY

On Wilhelmsburg island in Hamburg's River Elbe, a three-story building seems alive to the elements – shot through with sunlight, and sporting a sail-like canopy on its roof. This paradoxically named Soft House, tough enough to withstand the harshest elements and to last for a century, was awarded first prize in the International BauAustellung (IBA) design competition for sustainable urban development and was commissioned by a prestigious European building exhibition.

For one of its principle creators, Sheila Kennedy, Professor of the Practice in the Department of Architecture, the Soft House embodies pathbreaking design ideas she has been researching that mesh resilience, flexibility, and consonance with the natural world. "Our cities need to become more resilient and durable — in essence, softer," she says.

Kennedy and other architects had long sought ways of freeing our built environment from fossil fuel dependence. "Technology alone won't help accelerate the culture shift necessary to make this transition…Architects are well positioned to create new ideas that will help people take up the infrastructure transition in their daily lives."

A decade ago, the introduction of photovoltaics, LEDs and other energy-efficient components gave Kennedy a powerful insight: These new technologies were in fact, *material*—and could be integrated into building materials, advancing the infrastructure transition. After renovating an old Boston bottling plant, Kennedy & Violich Architecture (KVA) set up prototyping workshops, "a digital design and fabrication facility and a skunk works for electronics," says Kennedy. In this laboratory for new, disruptive ideas, KVA "abolished the disciplinary categorization between technology and architecture, creating a new model of practice," Kennedy says.

In this incubator, KVA cooked up designs to disrupt and upend architectural convention, generating viable building components by taking traditional building materials and integrating 'smart' features into them. KVA takes the position that "architecture can be enduring and simple, and that infrastructure should be more mobile and networked, enabling it to be updated regularly." From this principle flowed the notion that there should be "more physical engagement with infrastructure in architectural design," says Kennedy, so people "interact with the new infrastructure in design elements they find pleasurable and compelling."

The Soft House neatly captures this strategy: A dynamic canopy made of textile strips embedded with photovoltaic cells tracks the sun like a flower to maximize solar energy harvest and admit light and shade into the house. Residents can adjust this canopy to change the view. Inside, moveable curtains integrate LEDs for lighting, and partition living spaces according to residents' daily needs. Powered by the solar canopy, curtains also reflect heat in cold weather to create local climate zones. The house, made of solid, sustainably harvested soft wood, incorporates environmental sensors and wireless Internet connectivity. When bad weather approaches, its canopy pulls in automatically, like a boat with sails. "Instead of the HVAC unit on the roof," says Kennedy, "we have a house that connects people with wild, urban nature."

Kennedy is excited about extending resilient and adaptive design principles to bigger projects — mid-height buildings, for instance. New ventures may incorporate low-carbon, inexpensive biomaterials, such as seaweed insulation, courtesy of MIT researchers. The infrastructure transition won't happen instantly, but, says Kennedy, "We live in a time that when something material is made, it speaks to others. Objects and buildings are powerful, and they will be copied, which is good."

~ LEDA ZIMMERMAN

Sheila Kennedy creates a Soft House: Tough enough to withstand the harshest elements and to last a century. Len Rubenstein

ALMOST MIDDLE CLASS

Christine Walley, then the teenage daughter of a Wisconsin Steel mill worker, watched her father lose his job, his pension, and his hopes for the future, when the mill in Chicago abruptly shut down in 1980. Thirty-four hundred factory jobs were lost overnight. And when the jobs went away, so did an entire community's chance at reaching a stable, middle-class life.

Today, an associate professor of anthropology at MIT, Walley is on a quest to make sense of her family's story, and through this inquiry, to explain the larger, lasting, and devastating effects of the deindustrialization of American cities. She is now author of *Exit Zero: Family and Class in Postindustrial Chicago*, which brings an urban anthropological perspective to her family's story. The book is part of a project that will include a film and website focusing on first-person accounts of the demise of the steel industry in Southeast Chicago.

Steel mills formed the very backbone of this part of Chicago, as tens of thousands of immigrants flocked to the city for the good jobs and stability the mills provided. "Southeast Chicago arose because of the steel mills. You can even see it in how the neighborhoods were named, like Irondale or Slag Valley," Walley says. "People lived in the neighborhood, worked in the neighborhood, shopped in the neighborhood, and walked to work—creating dense, tight, social networks in these old, industrial areas."

The mills offered not only jobs, but a sense of purpose and meaning from the results of the hard, dangerous work. And they provided economic security for workers and their families, and seemingly, multiple generations to come. Wages rose. "People felt themselves transitioning to middle-class lives as the mills provided a form of economic upward mobility for entire communities. But for them, losing the mills knocked out this rung on the social ladder."

The loss of that rung had been profound for the Wisconsin Steel workers and for the southeast Chicago region. Some younger workers moved. Many workers suffered mental and physical breakdowns, and premature death. Walley's father stayed and worked at a series of odd jobs, but never found meaningful work. He was depressed the rest of his life. She once overheard him say, "We were almost middle class."

The postindustrial future of the region is uncertain. While plans are underway to convert the abandoned factory sites as well as the region's many landfills and pre-existing wetlands to parks, community groups are working hard to ensure that revitalization efforts will include new jobs for residents and not simply recreational spaces for non-residents in a gentrifying city.

Now, as an anthropologist, and one whose life was altered by the closing of the mills, Walley argues that much has been lost beyond the actual jobs. "The assumption that this was simply an evolutionary movement forward from an industrial economy to a more progressive postindustrial "new economy," doesn't account for what was being lost in terms of the larger society. Statistics don't convey what it meant for people and communities. The cost is a loss personally, socially, and economically. When you have the loss of industry, then it's not only an economic loss and a loss of jobs, but it's a loss to the whole foundation of society."

~ LAURIE EVERETT

Christine Walley's *Exit Zero*: Part of a project that includes a film focusing on personal accounts of the demise of the steel industry in Southeast Chicago. Len Rubenstein

Larry Sass: A vision for new buildings to rise faster, use fewer resources, and cost less, thanks to digital fabrication. Len Rubenstein

3-D PRINTED BUILDINGS FOR A DEVELOPING WORLD

In Larry Sass's vision of the future, new buildings will rise faster, use fewer resources, cost less, and be more delightful to the eye than ever before. This transformation will be made possible through digital fabrication, a new delivery system for buildings that will enable architects to send computer-designed plans directly to manufacturing – perhaps soon to be 3-D printed.

"There's a lot of research on the design and organization of cities and how cities should develop over time. But there is almost no research on how to manufacture and make the buildings you design," says Sass, who does exactly such research as an associate professor of architecture and director of MIT's Digital Design Fabrication Group.

Building construction essentially hasn't changed since the 1800s; it remains slow, labor-intensive, and costly. Digital fabrication offers a streamlined process in which a computer-designed building can be manufactured as a sequence of precision-cut, interlocking parts that can be pieced together on site like a giant jigsaw puzzle, saving on parts and labor.

"It's the right delivery system for the developing world, because the developing world doesn't have an infrastructure of tools, air guns, saws, and power," Sass says. Startup costs are also low since computer numerical control (CNC) machines are inexpensive and portable. "Design and high-quality construction is mostly for the rich," says Sass, who was raised in Harlem. "I've always wanted to figure out how to bring design choice and architectural delight to the poor."

Digital fabrication relies on three technologies developed at MIT: CNC, invented in the 1950s to enable computers to control machines; computer-aided design software, created in the 1960s for drawing structures; and 3-D printing, a process that emerged in the 1980s for making solid models from digital designs. Combining these techniques enables designs to be tested accurately through rapid prototyping; the computer-drawn plans are so precise that any building that functions in prototype is guaranteed to scale up successfully.

"The Industrial Age was all about making identical copies of one design. The Information Age is about the simple manufacturing of infinite design possibilities through the application of a finite set of rules for manufacturing," Sass says. "The challenge is figuring how to write new software that allows you to decompose very large designs into thousands of small parts for manufacturing."

As a proof of concept, Sass built a digitally fabricated house for an exhibit at the Museum of Modern Art in New York in 2008. Prototyped at MIT at 1/6 scale, the full-size "printed house" was a complete success, taking just days to hammer together all 5,200 pieces.

Now Sass is developing ways to digitally reproduce objects directly from photographs in the hopes of speeding up the reconstruction needed after storms and other disasters. "You take photos of a house, run them through some software, and the machine makes all the components of the house that was just lost," he says. "Imagine. Using photos and large-scale 3-D printing, you could reconstruct someone's house in about six days."

~ KATHRYN M. O'NEILL

DO-IT-YOURSELF MANUFACTURING

Many cities on the planet now have a workshop equipped with computer-controlled tools making things, and a growing network of such shops around the world is sparking a revolution: do-it-yourself manufacturing. These shops — dubbed fab labs and spawned at MIT — and their brethren are poised to reshape cities economically and socially.

City dwellers making their own furniture, housewares, and consumer electronics is a radical departure from today's world of global brands and globe-spanning supply chains. And it's a gleaming vision of a sustainable and prosperous future that also turns the clock back centuries to a time when cities were self-sufficient and people had the means to build what they needed.

In addition to laser cutters and large-scale milling machines, fab labs also include 3-D scanners and printers, micron-scale milling machines and sign cutters, and tools for assembling electronics and programming embedded processors. These are all connected by custom software and materials. MIT's Center for Bits and Atoms (CBA) set up the first fab lab a decade ago. Since then the technology has spread virally, with several hundred operating worldwide, said Prof. Neil Gershenfeld, CBA's Director and originator of fab labs.

Do-it-yourself manufacturing is helping cities evolve by sparking local, small manufacturing businesses and teaching young people to be self-sufficient. All fab labs have the same machines and software so projects can be shared and the knowledge of how to use the labs can spread. A Fab Foundation supports the network, and a Fab Academy trains the people.

Fab labs, along with supporting cities in developing countries, have also proved vital to developed cities with significant economic challenges, like Barcelona and Detroit, and in underserved communities elsewhere, like Amsterdam and Boston. Vicente Guallart, founder of the Institute of Advanced Architecture of Catalonia, set up a fab lab in Barcelona and is now the city's chief architect. "They're filling the city with fab labs," Gershenfeld said.

Barcelona sees do-it-yourself manufacturing, along with urban agriculture and local energy production, as a way to rebuild the city's tattered economy, said Gershenfeld. "The crucial connection between digital fabrication and the future of Barcelona is technical self-sufficiency," he said. "The goal is for the city to be globally connected for knowledge but able to locally produce what it consumes."

In the past, cities were less reliant on trade and transportation networks for their citizens' basic needs. The do-it-yourself and local movements aim to reduce cities' regional and global dependencies. "It's a modern return to an older notion of a city-state," said Gershenfeld.

Fab labs also contribute to cities' social sustainability. In Barcelona, where youth unemployment is 50 percent, the labs teach skills and allow people to make things to use or sell. They give at-risk youth fulfilling and engaging activities and the opportunity to develop. They're doing the same for the inner cities of North America.

The first fab lab was established at the South End Technology Center in Boston by Mel King, former MIT adjunct professor. The lab hosts the Teach to Learn, Learn to Teach program that teaches children to teach each other. A group of fab labs in Detroit run by an MIT graduate also focuses on youth. It "delivers better life outcomes than the social services that were on offer for them," said Gershenfeld.

Neither urban planners nor fab labs' developers initially considered the role do-it-yourself digital fabrication could play in the evolution of cities, said Gershenfeld. But fab labs experiences around the world have become an unexpected road map for empowering cities, he said. "That wasn't really anybody's agenda or plan, but grew naturally from the growth of the network," he said. "It's a fundamental change of the notion of civic infrastructure."

~ ERIC SMALLEY

Neil Gershenfeld with students at Boston's South End Technology Center: Fab labs sparking a revolution in do-it-yourself manufacturing. Len Rubenstein

Sep Kamvar's Social Computing Group: Making 10,000 data visualization maps, so residents can view cities like never before. Len Rubenstein

DATA VISUALIZING HEALTHY CITIES

When Sep Kamvar moved to Cambridge after a dozen years in San Francisco, he was struck by how different the two cities felt. The inquisitive computer scientist, artist, and entrepreneur began to explore how Cambridge's layout informed his feelings. He tapped his experience studying the visual representation of data, which provides insights into complex data by communicating key aspects more intuitively, like revealing trends in social networks, summarizing huge scientific data sets, and predicting business opportunities. In short, he began to make data visualization maps.

"Every map makes editorial commentary," said Kamvar, the LG Career Development Professor of Media Arts and Sciences. "A mapmaker communicates what he believes to be important in a city by what he includes in the map, and what he leaves out." While roads and buildings are typically included, trees and sidewalks, for example, are often excluded, he said.

The Social Computing group is making 10,000 maps – 100 maps of 100 cities, including Boston, Cambridge, MA, and New York City. The maps show a wide range of information, including public transportation efficiency, school route walkability, and estimates of footfall density on sidewalks. "The residents will be able to see this narrative of their city that they haven't been able to see before," he said.

Building these maps requires software that can analyze large amounts of data. In addition to recording cities' shapes, software is shaping cities, according to Kamvar. As he was leaving San Francisco for MIT, Kamvar noticed a boom in food trucks and wondered what was driving the trend. "It was because of Twitter," he said. Food trucks that weren't properly licensed could avoid parking in the same place, he said. "They would park in different places every day and tweet out their location. They could now have a following without being caught," he said.

Kamvar is planning to use data visualization to help cities change in conscious ways. He likens the work to performing acupuncture on a city. An acupuncturist's goal is to unblock energy paths so the body can heal itself. On the scale of a city, one of the biggest energy blocks is lack of information, said Kamvar. Making the information available "catalyzes the city's natural, intuitive ability to heal itself," he said.

For example, when sidewalks are too narrow, people are more anxious because, consciously or not, they're uncomfortable being close to traffic. One approach is to make a map that shows sidewalk widths and places where street parking utilization is under 50 percent. The map gives residents and city officials missing information: places where sidewalks can be widened, he said. "Visualizations really impact the way people think about the world around them," he said.

Kamvar is also taking big data and data visualization in an unusual direction: from aggregate to individual. He's made "experiential" data visualizations that uncover patterns in the data and explore data items individually. "Each individual data item is a very rich story," said Kamvar. "It's very important to build tools that enable us to go back and forth seamlessly between micro and macro — between large-scale data analysis and the exploration of the individual stories that make up that data."

~ ERIC SMALLEY

On the roof: Judith Layzer with sedums, drought-tolerant plants, which insulate the house below, keeping it cool in summer and warm in winter. Len Rubenstein

GREENING GRAY INFRASTRUCTURE

"It's visceral with me," says Judith Layzer, associate professor in the Department of Urban Studies and Planning. "I hate waste." As a social scientist who helps cities craft smart policies for reducing environmental impacts, Layzer sees a lot of squandering, but one area that has recently earned her particular scrutiny is stormwater runoff.

What was once an obscure matter for municipal managers is swiftly becoming an urgent, national environmental challenge: the EPA estimates that 10 trillion gallons of untreated rainwater and melted snow pour off roofs, roads, parking lots, and other impervious surfaces each year, overwhelming sewer systems, infiltrating rivers and waterways, threatening drinking water supplies, and degrading ecosystems.

This "gray" infrastructure depends on steel-colored networks of cement and metal pipes, valves, pumps, and energy-hungry treatment plants. As urban development escalates, and climate change brings rising seas and monster storms, current water management systems are failing, says Layzer. Their repair and replacement is increasingly expensive in a global economy where there is stiff competition for building materials. Cities desperately need an alternative to infrastructure that pollutes an ocean's worth of precious fresh water annually, then dumps it at enormous cost.

The answer, Layzer believes, is green stormwater infrastructure. This comprehensive approach emulates nature by directing stormwater into soil and other permeable surfaces, where it can first nourish trees and plants, and then percolate downward. Stormwater becomes purified on its way to underground aquifers or rivers and lakes, protecting watersheds and ecosystems. Even better, says Layzer, "It is a solution that not only solves the problem, but gives you extra benefits." That's because this method of stormwater remediation "has the advantage of using much less energy, creating new habitats, and improving public health by cleaning the air and mitigating the heat island effect," Layzer says.

As director of a national Urban Sustainability Assessment Project, Layzer is developing a methodology to help busy city managers identify the best and most cost-effective environmental practices. She is convinced that green stormwater infrastructure can deliver on all fronts. She points to Philadelphia, which may be the poster child for gray-to-green infrastructure conversion. To meet Clean Water Act requirements, the city has agreed to a 25-year transformation of gray infrastructure into "greened acres," diverting up to 90% of annual rainfall from these areas to green roofs, porous paving, rain gardens, and bioswales, gentle slopes that use vegetation and compost to filter silt and pollution from surface runoff water. The city estimates its green investment will save billions over maintaining its old, gray system.

With MIT graduate students, Layzer is undertaking a green stormwater infrastructure assessment that explores the experience of Philadelphia and other U.S. cities. This work will be posted online as an open source tool for city planners, and then incorporated into a book Layzer says will "reconceptualize cities as parts of ecological systems rather than simply as built environments." The bottom line, Layzer hopes to demonstrate, is that gray solutions are financially and ecologically unsustainable. They are also "wasteful, unbeautiful, and inelegant" when compared to "the miraculous system that nature came up with for cleaning the water and the air and creating a healthy habitat."

~ LEDA ZIMMERMAN

FROM POLLUTANTS TO SMART POLICY

Noelle Eckley Selin's work to cut air pollution in urban areas has attracted the attention of environmental policy makers in China, Western Europe, and the United States.

In part, Selin's research focuses on understanding where pollution comes from — say, power plants or car exhaust — to where it's going, like right into major cities. Then, "I ask questions about the policies or interventions that would be most effective in controlling it," says the Esther and Harold E. Edgerton Career Development Professor.

Selin works with multiple computer models that, when linked, not only track air pollution, but also determine its economic impact as measured by effects on human health. The models, for example, can compare the levels of pollutants emitted with and without various regulations, then monetize the costs for both scenarios associated with lost labor and health care. The work focuses on ozone and particulate matter because those pollutants are responsible for the vast majority of health costs associated with air pollution, says Selin, who has appointments in the Engineering Systems Division and in the Department of Earth, Atmospheric, and Planetary Sciences.

Using these models, Selin and colleagues have shown that air pollution in Europe and China has had a major impact on those regions' respective economies. The team found that air pollution in China, for example, cost the country $112 billion in 2005, up from $22 billion in 1975.

Similarly, the team reported that three decades of air pollution in 18 Western European countries resulted in an average annual economic loss of about 220 billion Euros as of 2005. The researchers further found that the application of a set of air-quality policies could save the region more than 37 billion Euros in the year 2020 alone.

Those numbers are larger than those arrived at by others because Selin's approach includes the impact of pollutants over time, an effect similar to compounding interest. "Traditional methods of assessing the burdens of air pollution that are used in a lot of regulations don't take that into account. Our approach addresses this more comprehensively," says Selin, who is also affiliated with the MIT Joint Program on the Science and Policy of Global Change.

Recently, Selin has been applying her modeling techniques to the effects of different potential climate policies on air pollutants — and human health — across the northeastern U.S. That work, which is funded by the Environmental Protection Agency, is attracting the attention of state and regional regulators who "want to know what to do better," Selin says.

Although trained as an atmospheric chemist, Selin thrives on the interdisciplinary nature of her work. "It goes beyond looking at one small corner of a problem to looking at the problem holistically. You get to build on lots of different kinds of analyses and disciplines, from economics to atmospheric chemistry to health impacts."

Selin hopes that her work will lead to smarter policy making about air pollution and how to manage it. "That, in turn, could help make people healthier over the long term, both in the US and, ultimately, worldwide," she says.

~ ELIZABETH THOMSON

Noelle Eckley Selin's work to cut urban air pollution: Attracting attention of environmental policy makers across the world. Len Rubenstein

SPECTRVM

600 Memorial Drive W98-300
Cambridge, MA 02139-4822

Massachusetts Institute of Technology

Non-Profit Org.
U.S. Postage
PAID
Cambridge, MA
Permit No. 54016

Address Service Requested

spectrvm online

spectrvm.mit.edu

@MIT_Spectrum

facebook.com/Spectrum.MIT

giving online

http://giving.mit.edu/

NOT JUST MEN IN SPANDEX

Michael Lin and Sandra Richter have designed a future vehicle for bike lanes that's one part bike, one part car, and eight parts a solution to congestion, pollution, obesity, and aging.

Grad student Lin and researcher Richter—both at the Media Lab—say one goal of the design is to democratize bike lanes, alerting commuters that biking isn't just for men in Spandex—but for men in suits, women in skirts, the elderly, and anyone who doesn't want to mess up their hair in the rain.

The vehicle is motor-assisted and has a top speed of 25 mph, but by pedaling fast you can zoom along to 40 mph. It has three wheels for stability and a soft cover made of smart fabrics for protection against the weather. It also has heating and cooling options, and a seat in the back for a baby or groceries.

"We're promoting low energy use and a healthy lifestyle," Richter says, adding that it's called a Persuasive Electric Vehicle (PEV), because it persuades commuters to get more exercise and to travel green.

"This vehicle is designed to share—not to own. By sharing you don't need as many vehicles, and therefore, it reduces congestion," says Lin, who was raised in Taipei, Taiwan and was motivated to design the PEV after witnessing that city's streets choked with cars.

The vehicle folds to half its size for storage and is intended to be integrated into a bike-sharing program. For a monthly fee, you can pick it up and drop it off at charging stations on the street.

Richter says: "We're hoping the vehicle will encourage more people who normally don't travel by bike, to get in a bike lane."

~ LIZ KARAGIANIS

Michael Lin and Sandra Richter: Designing a future vehicle for bike lanes. Len Rubenstein