ICIS Conference on the Coordinated Renewal of Civil Infrastructure Systems for Sustainable Human Environments

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CONFERENCE REPORT

Sustainability and Coordinated Renewal of Civil Infrastructure Systems

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PREFACE

The sustainability of community development connotes human activities that are in balance with the Earth's resources and do not exceed its capacity. Infrastructure is a major component of community development and as such the extent to which infrastructure promotes sustainability is a critical issue. ICIS selected the coordinated renewal of infrastructure in light of sustainability as a major thrust or organizing principle for its programs.

This conference was ICIS' key event to explore the relationship between the coordinated renewal of infrastructure and sustainability with participants from a wide variety of disciplines. In addition, to identifying some of these relationships, the major outcome of the conference was to derive directions or an agenda for ICIS in light of the concept of sustainability.

Contents

1. Sustainability and Civil Infrastructure Systems: Framing the Issues

The purpose of the conference was to discuss civil infrastructure systems and their renewal from the perspective of sustainability. William Petak introduced these concepts to the audience and established a working framework for the discussion of papers relating to various aspects of civil infrastructure, by explaining why the concept of sustainability was chosen. He argued that the condition of our infrastructure reflects society's values and that the concept of sustainability provides linkages between infrastructure and communities. Moreover, he said this concept is useful because it allows for an integrated vision and thinking process.

These ideas are explored in more detail in a background paper, "Coordinated Renewal of Civil Infrastructure Systems for Sustainable Human Environments," by William Petak and Richard Schuler. The paper begins by maintaining that "arranging for the coordinated renewal and evolution of our system of civil infrastructure is a daunting task, but it is essential if we are to sustain the advanced human environments we have come to expect." In order to address this essential goal, the authors make the point that "one possible way of capturing the multi-faceted essence of infrastructure is [to] view it through the lens of another, equally complex concept: sustainability. Efforts to systematize the renewal of infrastructure have as one objective sustaining those systems. But in a broader context, to the extent that infrastructure supports a wide range of human activity, the meaning of sustainability as it relates to infrastructure takes on a larger, ecological meaning. And of course, given the substantial public apathy about our civil infrastructure systems, perhaps the first task is to sustain public attention."

The authors also provide working definitions for these concepts. As will be described in later sections of this report, defining these concepts is challenging, and there were different perspectives on how this should be done. In the Petak-Schuler paper, coordinated renewal is defined as "the intended evolution of a system, not renewal of a particular structure, and it includes everything from repairing, replacing, and moving infrastructure to make the system achieve its functional goals without doing extraordinary damage."

The authors go on to say that the objective of coordinated renewal is "the viability of urban environments for human activity. Sustainability is a useful concept to characterize viability in spite of the elusiveness and value-laden nature of its precise definition. A sustainable urban area is one that is "in balance" from a systems perspective. That is, it uses resources in a manner that does not (or minimizes) the disruptions in other places and in future time periods."

The paper also provides an operational definition of sustainability. Petak and Schuler argue that it "is based upon the principle that development within a designated area is not to consume resources at a rate faster than their natural replenishment thus allowing the system to continue indefinitely without degradation of its internal resource base and the standard of living of the people and ecosystem within it."

One aspect of sustainability that was discussed by the group throughout the conference was the fact that if civil infrastructure projects, and development in general, are to be sustainable, they will have to have input from all stakeholders. It was pointed out, however, that such participatory decision-making frameworks present challenges in themselves, such as increased costs and the

risk of inaction. The authors of this paper also discussed public participation and make the point that “given the variety of perspectives and contexts in which the concept operates, its inevitable uncertainty, and likelihood of change, then the process of deciding on acceptable levels of sustainability should be iterative and seen as a process involving many parties.”

Petak and Schuler conclude that sustainability can be considered from at least four perspectives in thinking about, planning for, and managing infrastructure renewal. The perspectives are:

1. Sustaining public interest and awareness about this essential component of modern societies.

2. Designing, building and maintaining infrastructure so that the essential services derived from it are sustained.

3. Evolving a system of infrastructure, and the linkages between individual components, so that they serve the needs of a constantly changing society (economically, demographically, politically, and technologically).

4. Adapting these infrastructure systems so that they serve as facilitating mechanisms for configuring human settlement patterns and social and economic systems in ways that are sustainable in terms of resource use, environmental impact, and civil social relationships. Furthermore, to be sustainable, each community must have a voice in these decisions.

Integrating these concepts and thinking about how different disciplines can contribute to sustainable civil infrastructure were two topics discussed extensively throughout the conference. These discussions, along with presentations and various comments, are documented in the remaining sections of this report.

2. Introduction and Participant Perspectives on Civil Infrastructure Systems

Introductory Remarks and Perspectives

Jo Ivey Boufford, Dean of the Robert F. Wagner Graduate School of Public Service, provided the University and School context for the conference's theme. She began by describing the renewed economic strength of New York City and the opportunities this represents to New York University's academic environment. As "a private university in the public service," the Wagner Graduate School of Public Service is at the heart of NYU's mission. Students obtain a set of core competencies and then specialize to become practitioners and researchers who take their experiences out into the field. The School's urban planning program is greatly enriched by the opportunities presented by the ICIS project.

Boufford also noted similarities between civil infrastructure and her own field, public health. The two have a similar focus and face similar political realities. Like civil infrastructure, the public health infrastructure is invisible. The regulatory and technical systems protecting the quality of water, food, and air, for example, are only noticed if they fail and an incident occurs that causes a health problem. She also mentioned that successful infrastructure systems require disciplines to collaborate in getting citizens more involved in discussions about these "invisible" topics that can affect their everyday lives.

Professor **Rae Zimmerman**, Director of the Institute for Civil Infrastructure Systems (ICIS) at the Wagner School, introduced the subject of sustainability and coordinated renewal as a key focus of ICIS. ICIS originated from the idea that the services and structures that constitute infrastructure need to connect more to the people they serve and the communities in which they exist and from which they draw resources. Why does ICIS care? Infrastructure supports systems, and systems sustain our lives and cultures. ICIS is interested in bringing a system of disconnected structures and services to interconnection points - to reach a common ground about people and their environment and to view physical structures and discrete services as an extension of the natural resource base. How is ICIS structured to deal with this issue? As a consortium of social scientists and engineers, ICIS is building a network among various interest groups. Today is just the beginning of a conversation to emphasize and further define those connections. Zimmerman said that the authors of the papers and the participants at the conference are a critical part of this effort and provide invaluable insights into this issue.

Participants' Impressions of Infrastructure

One of the challenging aspects of working on civil infrastructure systems is the wide variety of systems and projects encompassed by the concept. In thinking about the sustainability of civil infrastructure systems it quickly becomes apparent that only a multi-disciplinary discussion can be meaningful. As an illustration of the importance of infrastructure and its far-reaching effects, participants were asked to discuss their interest in infrastructure and describe what piece of infrastructure most captured their imagination as they were growing up. It is these early images of infrastructure that shape how people think about infrastructure as adults. The responses are summarized below (the complete affiliations of the participants is given after the executive summary).

Ernest Tollerson, *New York Times*. Growing up in Washington, D.C., he remembered the trolleys and light rail lines as a pleasant way to get around that made the city seem more manageable and less congested.

Christine Anderson, *Department of Public Works in Eugene, Oregon.* She remembered the first street she grew up on because it had a lot of the characteristics that were part of the feel of what the neighborhood was all about.

Daniel Davis, *National Science Foundation.* Growing up in Philadelphia, he remembered the elevated train that went underground below the river and recalled thinking how exciting it was knowing he was going under water.

Dave Mammen, *Institute of Public Administration.* His infrastructure thoughts are from this morning's walk to the conference to the subway, through a local park. He was fascinated by how different people use the park in different ways throughout the day. It made him think about the way infrastructure concerns a lot of different pieces of the community.

Dick Martin, *Georgia Institute of Technology.* He was born in Saigon, French Indochina, then moved to Hawaii, and attended Pratt Institute in New York. He is interested in the built environment, because we spend our time in it. Thinking about infrastructure, he asked "Why do we always do it wrong?" and gave Los Angeles as an example. Either that stops or we stop.

Russell Dynes, *University of Delaware.* He recalled the drive from India to China in a truck, remarking, "I remember that road."

Tokue Shibata, *Tokyo Metropolitan University.* He is interested in the automobile industry and its connection to highway construction. He said that for the first time, the automobile industry is scared. The automobile is the symbol of the economy, so infrastructure has an industrial economic basis.

Charlie Trautmann, *Sciencenter in Ithaca, New York.* His memory was of 5:04 pm October 17, 1989. He was teaching in Palo Alto, on electric power transmission lines, when the San Francisco earthquake hit. He was struck by how different that experience was from the 1906 earthquake because of the preparation that had been done since that time. When visiting San Francisco a year later, he was amazed to find that many traces of the earthquake were gone among the residences in the Marina District

Dick Schuler, *Cornell University; ICIS Executive Committee.* His earliest recollection of infrastructure was in Allentown, Pennsylvania, where he grew up. There he remembered the steam engine that pumped water, which he passed every day on his way to school.

Patrick Killackey, *New York University, ICIS Project Manager.* He thought of the Gowanus Expressway and the personal impact it has on him when he runs in the area. He is struck by the fact that it establishes a dividing line between neighborhoods, creating a very different world on the other side. The impact of a single piece of infrastructure is remarkable.

Gary McAllister, *Bechtel.* He thinks of the Proton Therapy Cancer Research Center at Massachusetts General Hospital, because of his personal involvement in putting it together.

Rae Zimmerman, *New York University, ICIS Director.* She called attention to catch basins, because they catch all our mistakes. As such they are intertwined with communities and embedded in what we do, being close to people and their habits. We don't really know about them. They are not as visible as larger waste treatment plants.

Dick Wright, *National Institute of Standards and Technology (formerly).* His memory is from his 8th grade guidance session, when he was asked what he wanted to study in college. He looked at civil engineering and saw roads, bridges, and water supply and thought these things were really important to people, and that was what he wanted to do.

Roy Sparrow, *New York University, ICIS Executive Committee (co-chair).* He was trained as a political scientist, and studies organizations and transportation. His answer to the question was to recall a contrast. He grew up in rural North Carolina, where there was no electricity, and watched the electrification of his relatives' homes. There was a lot of stringing wire across the landscape. While he understood the benefit of electricity, he also found the wires really ugly. He was astounded when he first arrived in New York City, where there were no power lines to be seen.

Dick Netzer, *New York University.* He remembered an uncle who used to travel to California twice a year in the early days of transcontinental flights, taking the two-day service that stopped in Kansas City. It was such an event to pick him up at La Guardia and see the Pan Am Clippers in the water next to the shacks at the airport. The whole system was very fragile. He noticed that the water was 18 inches below the runway, and wondered what would happen if the water rose.

Stuart Harris, *Confederated Tribes of the Umatilla Indian Reservation.* As a child, he remembered picking berries with his grandfather and asking him how everything works together. Environmental science, which is his field, shows interrelationships and how everything depends on everything else. His grandfather gave him this example. You are sitting on a road, where the elk come through in the fall. Below was a stream, which is also a road, where the fish come back every four years. His memories of infrastructure are of aspects of the natural environment where cycles repeat themselves.

Al Grant, *a consulting civil engineer.* He remembered buying a moped at the age of 60 to make himself feel younger, and discovering a bikeway path. He soon found out, however, that mopeds weren't allowed on the path, and his moped was stolen anyway.

Tom O'Rourke, *Cornell University; ICIS Executive Committee (co-chair).* His memory was of holiday lights and TV. You can't have either without electricity. Both are inside. Television is the most visible aspect of the telecommunications system to most people. That says something about the physical and resource landscape created by infrastructure, and also the cultural landscape.

Jennifer Wolch, *University of Southern California.* She shared her childhood memories of growing up in the San Francisco Bay area and the wildlife refuges in the East Bay that were part of the water district. These were a way of finding out about the environment. Her other memory is of seeing a large chunk of the Santa Monica Freeway lying in the middle of one of the large boulevards in Los Angeles in 1994 and noticing how adaptable people were in finding alternative routes. She saw this as the creative use of infrastructure.

Nancy Connery, *infrastructure consultant; ICIS Executive Committee.* Her most formative infrastructure experience was on January 2, 1980, the first day of her job as the director of the transit unit for the Office of Management and Budget in New York City. That day 40% of the subway system failed. This was a pivotal moment in infrastructure history, and it led to a major capital rebuilding of the system in New York. It also taught her a lesson that continues to drive her interest in and enthusiasm for infrastructure today.

John Falcocchio, *Polytechnic University; ICIS Executive Committee.* His images of infrastructure fell into several stages. First, he remembered growing up in a small town in Italy and his fascination with the train and the way it connected his town to Rome, the nearest city. A second memory was the sound of the ringing of the phone. Third, he remembered the enormous underground space in Caracas, Venezuela, which was an environment that people worked and lived in without fresh air or sunlight. In addition, when he moved to the United States, the first thing he noticed was that there were no sidewalks in the suburbs.

Bill Blosser, *CH2MHill.* He works in urban planning and environmental impact assessment, and his interest is in bringing sustainability into building. His memory of infrastructure dates from around 1960, when he was 15 and worked as a boatman for the Sierra Club, taking trips through Glen Canyon on the Colorado River. Here the river was a piece of infrastructure in and of itself. When the Glen Canyon Dam was inundated, he recognized a case where one piece of beautiful infrastructure disappeared as another one was created. This illustrated the power of infrastructure to change.

Al Wallace, *Rensselaer Polytechnic University.* His memories include taking the train from Rensselaer, New York to the Great Lakes. He was on a National Science Foundation (NSF) team for the *Exxon Valdez* spill, and Vice Chair of Information Systems at the NSF. He was an information systems specialist in Athens, Ohio, and later moved into decision sciences and information technology.

Jo Ivy Boufford, *New York University, Dean.* She grew up in the South and remembers taking the train from Atlanta to Auburn, Alabama, passing through small towns along the way. Being old enough to do it herself was like a rite of passage. She contrasted this with coming to New York City in 1971 and working in the South Bronx and seeing the way that area has changed over the last 25 years, from the Third Avenue El and lots full of rubble, just a devastated environment, to beginning to see real people behind the windows in the buildings instead of paintings. She saw this as a paradigm shift.

Michael Replogle, *Environmental Defense Fund (EDF).* He was trained in civil engineering and sociology. His earliest memories are of riding the Long Island Rail Road and coming to see

the Macy's Christmas displays and seeing all the buildings in the Manhattan skyline. He also remembers riding in the trolleys in the suburbs in Pennsylvania, and regarding the trolley as his ticket to freedom/ independence. Another memory is of the water treatment plant he built in Utah and seeing the water transformed from brown sludge into clear drinkable water. He believes that the Netherlands has the most awe-inspiring infrastructure, for example, the sea wall and bicycle paths, with 40% of the trips there made by bicycle.

Michael Oppenheimer, *Environmental Defense Fund (EDF).* Infrastructure brings up both positive and negative experiences for him. His positive memory of infrastructure was of the subway, going from Manhattan to Queens. In its operations, New York City Transit Authority is like a railroad, but the subway is more than a railroad – it is a way of life. It is hard to describe how much the subway means to a boy. His negative memory was of the Glen Canyon Dam, which he sees as the greatest American environmental crime of the century. He also spoke about his neighborhood in Bayside, Queens, and the loss of 204th Street as a result of the construction of the Throgs Neck Bridge and the Clearview Expressway. When Oppenheimer was a teenager, Robert Moses eliminated one block and dug a 20-30 foot trench. So a cozy neighborhood was turned into a trench. As part of this project, the houses on 204th Street were actually placed on a truck and moved to what had been a golf course. Now he can go visit his neighborhood in a different place, but it is not the neighborhood. The lesson he learned from that is that there is more to a neighborhood than houses.

Richard Little, *Board on Infrastructure and the Constructed Environment, National Research Council*. He grew up in New York City and remembered the blackout of 1965. He also remembered being in a Long Island Rail Road train in the 1980s that broke down because of smoke conditions prior to departing. What struck him was other travelers, resignation and sense of being used to disruption. Nobody seemed to find the incident exceptional. People are more than infrastructure; they are more enduring.

Amy Helling, *Georgia State University*. She remembered taking her students to a combined sewer overflow (CSO) facility in Atlanta. The first reaction was quite negative. The fashionable and rather young students were quite vocal in expressing their repulsion, they walked into the CSOs holding their noses. They said things like "the place stinks." But after the role of the facility was explained to them, they became more interested in its existence. She hoped that they would retain that interest.

Charles Thornton, *Thornton-Tomasetti*. He grew up in the East Bronx. It had a unique architecture – the Bronx Brigadoon. His house was on the water, in what looked like a very pristine environment. In fact, from the house one could see landfills, Soundview, Pugley's Creek, which was continuously on fire. The coke plant and wetlands were filled with all kinds of debris. Also close by was the Hunt's Point industrial area, La Guardia Airport, which meant constant proximity to planes, noise, etc., and Whitestone Bridge. People would fish in the flight path of La Guardia and in the main outfall to Long Island Sound. In sum, he witnessed the trashing of the Bronx. He said he lived with Robert Moses over his head.

William Petak, *University of Southern California; ICIS Executive Committee*. He remarked that as a young boy he first became conscious of problems with the infrastructure system while

sitting in his grandmother's kitchen watching a river exceed flood levels and do much damage. He also remembered that, immediately following receipt of his driver's license, he hit a large pothole in the road with his father's car creating the need for a front end alignment.

Vivian Loftness, *Carnegie-Mellon University*. She grew up in Washington, D.C., and she thought the most spectacular infrastructure in the city was the creation of green space of monumental proportion around the Mall and the impact it had on organizing the city. She was also intrigued by the divide of positive and negative memories in the audience.

Christopher Gordon, *Massachusetts Port Authority.* He grew up in rural Maine, and the telephone was astounding to him. He still doesn't know how it works, and he thinks it is the most amazing thing we have.

Luis Suarez-Villa, *University of California*. His earliest memories were of airports, because he spent so much time waiting in them. He remembered collecting timetables as a child in the airport, and he still collects them. Now he is fascinated by the Internet and knowledge infrastructure.

Richard Dattner, *Richard Dattner Architect.* He was born in Poland and came to the United States when he was nine years old to escape Nazi persecution. He fled through Italy and Havana. At that time and in that exceptional context, trains, seaplanes, and ships were used to escape and gain freedom. He saw infrastructure as freedom. His life has been spent creating order because his childhood had so much disorder, he said.

3. Perspectives and Conversations on Infrastructure - Discussion of Papers

The concept of sustainability draws from many different intellectual traditions. To explore how the coordinated renewal of infrastructure is viewed by a broad cross-section of society with varied professional backgrounds, scholars from a number of disciplines were asked to use their particular perspectives to address the coordinated renewal of infrastructure in a manner that sustains communities and their environments.

This section of the report presents participants' comments on and discussions of eight topics related to civil infrastructure systems and sustainable human environments. The discussions are based on papers that were prepared by selected participants and distributed to everyone in advance of the conference. A brief summary of these papers is presented at the beginning of each topic. For each paper, two or three participants were asked to prepare comments and present them to the group. Next, participants were asked to engage in a general discussion that was facilitated through what is called a "Samoan circle". Approximately 10 chairs were set up in the front of the room. All participants were invited to sit down and join an open discussion when they had a point to make and to leave their chair for another participant once they had made their comments. On the second day of the conference, the authors were asked to describe what they would do differently if they were to write their papers after hearing these comments and discussions.

Presentation of Conference Themes: Culture, Political Structure, Architecture, and Industry

3.1. Culture

The first paper discussed was "A Native American Perspective on Sustainable Infrastructure," by **Stuart Harris**, a consultant to the U.S. EPA Science Advisory Board and a coordinator for the Confederated Tribes of the Umatilla Indian Reservation. According to Harris, "sustainable development requires a robust and diverse natural resource base. It also requires a diverse and robust set of cultural and economic bases, and a recognition that mankind and his systems, forms, and patterns are inseparable from the evolving environmental basket into which he is woven. This has been taught for thousands of years as indigenous environmental management science. The role of infrastructure is, or should be, to protect values, biodiversity, cultural diversity, and land use options for future generations."

The first participant to comment on Harris's paper was **Luis Suarez-Villa**, a professor in the Department of Urban and Regional Planning at the University of California at Irvine. He summarized the paper in three main points:

1. The impact of infrastructure on natural resources and communities that are heavily dependent on natural resources is important and should be carefully analyzed.

2. Addressing environmental issues requires time and funding in order to allow for participation and analysis. Some communities, such as Native American communities, are less well equipped to do this, as they lack the necessary capital and resources.

3. There are two types of infrastructure. Ecological or environmental infrastructure includes food, transportation, and shelter. Cultural infrastructure includes technology, creativity, and data, which are intangible. It also includes institutional factors such as education and laws. In order to move towards sustainable development, ecological and cultural considerations need to be combined into a single eco-cultural framework with a holistic management system.

Suarez-Villa pointed out that the implicit perspective in Harris's paper is the tension between the usual criteria of efficiency and optimization on one hand, and cultural criteria on the other. The inclusion of cultural criteria may lead to what may, from the perspective of efficiency, be considered sub-optimal decisions. However, Harris's eco-cultural framework indicates that cultural criteria are necessary to achieve sustainability.

The second participant to comment on Harris's paper was **Jennifer Wolch**, Co-Director of the Sustainable Cities Program at the University of Southern California. Her summary of Harris's paper consisted of four main arguments, which she said, challenge dominant assumptions of urban geography and urban planning:

1. There is no nature-culture divide and no city-country divide. Instead, there is a contemporary theory of urban development, which considers economic and other forces and is the site of industries and other activities, and is based on the spatial organization of infrastructure. Nature is a key agent and actor in shaping the city and its infrastructure. Question: What would a theory that adopted an urban/nature perspective have taken into account?

2. What matters is sustainable livelihoods, not just development. However, planning is designed around growth and development. Today, livelihoods are at stake - how people support themselves in the world economically, socially, and spiritually. Only feminist urban geographers have recognized this issue.

3. Urban infrastructure appropriates ecosystem resources from places near and far. Resource appropriations create huge injustices. Urbanism recognizes linkages, but conceptual frameworks and policies typically fail to recognize ecosystem appropriation. We worry about pollution and congestion but less about depletion of resources – depletion of the forests and other systems that other people and cultures depend on. We don't focus on urban consumption and what it means - the ecological footprint of our civil infrastructure system.

4. Animals matter too. Humans are not the only things in the world. Urban planning and theory is very anthropocentric. If Stuart is right, we need a trans-species urban theory and practice to create kinship and solidarity - bringing animals back into the city. For example, in the Northwest, what is good for salmon is good for people. Question: What would an infrastructure system for a city look like if it were guided by these principles?

The third participant to comment was the paper's author, Stuart Harris. He described the planning process in his community, a process that is guided by the elders.

The top priority in the community is water. This means a clean source of water as well as the watershed itself, the soil, buffer zones that prevent abuse, and every aspect of its use. A whole network of infrastructure is needed to protect these things.

The second priority is transportation and how to keep people from creating roads and ruining places. This means considering the impact of cars and other vehicles in order to avoid losing soil and creating pathways for pathogens.

Harris also suggested looking carefully at the life cycle costs of resource use. For instance, what does it cost to use materials such as concrete and asphalt, bury infrastructure, and do other things that fracture ecosystems? These costs are usually not accounted for. However, there may often be major impacts associated with removing and transporting some natural resources. Such material extraction is usually for someone's economic benefit and not for the benefit of the culture. Consider, for example, old fence posts and wire. What is their life cycle, and what does it cost to get rid of them? Accounting for and having such costs would be very useful.

Harris also expressed concern over the current reliance on limited food crops. Whereas the elders in his community continue to speak about hundreds of varieties of crops that are used in one year, society at large depends on only about 12 crops. If you rely on just a few, you set yourself up for trouble when you have problems obtaining them.

Finally, Harris reminded the audience that "you are what you eat." You are how you treat other people. He noted that his community has existed in a particular watershed for about 10,000 years – it has not changed. As a result, they are part of their environment.

3.2. The Political Structure

The second paper discussed was "Infrastructure: A Political Analysis," by **Theodore J. Lowi**, a professor at Cornell University's Department of Government. In his paper, Lowi argues that "public works policy is the cornerstone of government and of politics in the United States." By using examples of decision making from New Haven (Connecticut), Iron City (Alabama) and DuPage County (Illinois), he concludes that "the public works process is certainly one of the worst processes in the American system from almost any and every perspective. It is bad in terms of the absence of the rule of law. It is bad in terms of the narrowness with which decision makers can allocate public resources. And it is measurably the worst to the extent that it enables locals to make social policies that would be definitively rejected if those policies were put before the public as a referendum."

The first participant to comment on the paper was **Christopher M. Gordon**, Director of Capital Programs at the Massachusetts Port Authority. He provided a synopsis by commenting on the political process of infrastructure projects, starting with the issue of federal funding versus local decision making. He explained how this dichotomy results in disconnectedness, with the end result being too project-oriented. The end result is that the secondary effects of infrastructure projects are not considered. Local decision making also means that the scope of analysis is often too narrow and parochial. The current system has been described as a system of pork barrel projects, with small pieces or chips that end up being traded for political gain. This results in

bizarre decisions based on power plays about where to put things which does not allow for a focus on the big picture with respect to infrastructure.

Gordon argues that this system is hard to change, because local people have the most at stake and want their particular projects. If things are changed, they will resist the federal government. This means there should be a broader national policy to frame the big picture. Unfortunately, infrastructure decisions today are made by unqualified people who often do not have a grasp of the big picture. There is also tremendous pressure to get projects done. While Gordon agreed with Lowi's main points, he said he did not know how to overcome this tension between local decision making and the big picture. He recommended a bigger policy – a broader one. He was unable to propose a solution: in his work, for example, there is a lot of pressure to get projects done on the one hand, but rigorous environmental review on the other.

The second participant to comment on Lowi's paper was **Russell Dynes**, a research professor at the University of Delaware. He began his comments on the political process by describing the reconstruction that takes place after an earthquake – using as an example the Lisbon earthquake, the first modern disaster. According to Dynes, decisions in cases of disaster reconstruction (regarding new structures and standardized procedures for fire walls, for example) are made in a very authoritarian way, which raises questions for him about the democratic process.

Dynes also noted that policy often creates politics. For instance, the federal government gives communities the resources to become disaster resistant without much in the way of policy. An example of how local decisions are disconnected from infrastructure policy is the unusual situation in Delaware, where there are 2,000 chickens per person and three counties are being piled up with chicken manure. The answer was to build a facility to burn chicken manure and to sell the ash as fertilizer. But what are the incentives to the private sector for infrastructure to do that? What about the role of privatization and tax incentives? The U.S. cultural climate is such that taxes are rarely reduced. Dynes also argued that while law needs to guide politics and policy, the law is not necessarily neutral. The law locks up people for stealing a goose, but not for stealing the commons from the goose!

The third participant to comment on Lowi's paper was **Ernest Tollerson**, a member of the Editorial Board of the *New York Times*. He started by saying that the anecdotes in Lowi's paper are depressing and familiar but not necessarily representative. Tollerson believes that despite the mistakes made during the New Deal, something was done right that spurred development in the South and allowed for other benefits. The Erie Canal was built, reflecting a capacity to do things. From the perspective of a lay person who has the privilege of thinking about issues and writing about them, Tollerson believes that the average American knows very little about the social value and utility of infrastructure. He cited as an example the fact that whereas most people know the gas mileage of their car, they probably know nothing about how the water supply system works or about what it means to run a city. Another area that most people are not knowledgeable about is the impact of a good public school system on property values. There is rate of return on infrastructure that a lot of people are unaware of.

Another issue raised by Tollerson concerns the appropriateness of the terminology used. He believes that the word “infrastructure” turns people off and should be replaced. The same is true

of the word “sustainability”. There is a need to break these concepts down into very basic things that the public can connect to easily and also to talk about why they are important in ways that people can readily understand. People are attracted by sound bites and numbers. They need to see what the value of infrastructure is.

As another example of his belief that things are not as bleak as presented in the Lowi paper, Tollerson mentioned Atlanta, where a new agency will oversee infrastructure projects in order to control sprawl. This is reason to be optimistic. And it shows there is the capability to do things. But in order for such changes to work, sustainability must become part of the American dream. Currently, it is antithetical to the American Dream. The sustainability movement is not yet part of the dream. Its value must be demonstrated to the public. A good example is NASA, which uses mass marketing to get people to buy into its projects. It is necessary to disseminate hard data that people can understand and to develop a mass marketing ability like NASA's.

Richard J.L. Martin, a professor at the Georgia Institute of Technology College of Architecture, then commented on the Atlanta experience. He noted that the board of decision makers consists of the same 18 people, who were selected because they don’t rock the boat.

3.3. Architecture

The next paper discussed was “Linking Sustainable Infrastructure to Buildings and Communities,” by **Vivian Loftness, Volker Hartkopf, Stephen Lee, Ardeshir Mahdavi,** and **Paul Mathew,** all from the Center for Building Performance and Diagnostics at Carnegie-Mellon University. They define sustainable design as “a collective process whereby the built environment achieves new levels of ecological balance through new and retrofit construction, towards the long-term viability and humanization of architecture. Focusing on environmental context, sustainable design merges the natural, minimum resource conditioning solutions of the past (daylight, solar heat, and natural ventilation) with the innovative technologies of the present, into an integrated 'intelligent' system that supports individual control with expert negotiation for resource consciousness.” They then provide seven principles for debate, arguing that sustainable infrastructures will depend on:

1. an integrative, human-ecological design approach;
2. changing approaches to land use and community fabric;
3. the effective use of natural, local, and global resources to reduce infrastructure loading and maximize infrastructure use;
4. the design of flexible, plug-and-play systems;
5. the use of sustainable materials and assemblies;
6. design for life cycle instead of first cost; and
7. the promotion of infrastructure to neighborhood amenities.

The paper concludes by stating that “it is time to move away from “go west young man” to build to last; from privatizing the profits while socializing the costs to life cycle ownership; from the thinning out of America to the pedestrianization of American communities; from the paving of America to the landscaping of America; from the crumbling of American infrastructures to

engineering longevity; from blinder movement through devastation to arrive at beauty, to continuous elegance; from a widening of the haves and have nots, to a shared future."

The first participant to comment on the paper by Loftness, et al was **Richard Dattner**, Principal at Richard Dattner Architect, PC. He summarized the paper using seven aphorisms.

There is no free lunch. Measuring life cycle costs should be a priority. Russell Dynes' example of the goose and the commons is terrific - the "Tragedy of the Commons" is the problem. We know what the costs of development are, but politicians don't care about what the impact and social costs of current projects and activities will be in the future. Hence, there is a conflict between individual interest and the greater social interest.

Walk gently on the land. Walk, bike, or take public transportation, but use a car only as a last option. We should see the entire Earth as an infrastructure. Originally, there was no infrastructure – the Earth gave us everything that was needed. With six billion people, this doesn't work any more.

Circle the wagons. The American Dream was "go West, young man," and this paper suggests bringing people together instead. Rather than always thinking in terms of moving to the next ring of development and leaving behind poor people and congestion (i.e., building single-family houses in areas like the Bronx that don't share in the total social costs of infrastructure), development should bring us together, and we should make more intelligent use of infrastructure.

Waste not, want not. Use only what you need. If you can open a window to cool down, do that. As a next option, use a fan. As a last option, use an air conditioner. This concept of ascending service strategies often makes economic sense. In Switzerland, for example, the use of air conditioners is discouraged by law for many commercial structures.

Whatsoever you do, do it with all your might. Value beauty. People do not consider the aesthetics and timeless beauty of infrastructure often enough.

"A stitch in time saves nine." This refers to the valuation and required continuing maintenance of American infrastructure. If we knew that our infrastructure was worth $x trillion, we could better determine the cost of adequate maintenance. For example, New York City Comptroller, Alan Hevesi recently completed a study of the value of the city's infrastructure – schools, subways, public buildings, etc. Private companies and households budget for maintenance. However, as a nation we don't value what we have or plan for its preservation.

Think about social sustainability. A quotation from Rabbi Hillel summarizes this: "If I am not for me, who will be? If I am for myself alone, who am I? If not now, when?" There are many factors that affect sustainability, but Rabbi Hillel said they all come down to one: "Do not do unto others what would be hateful to you." The rest is commentary.

The second participant commenting on this paper was **Bill Blosser**, of CH2MHill, where he supports the sustainable development practice. He agreed that the seven principles presented in the paper summarize the whole issue very well. According to Blosser, members of the building

industry have gone farther than anyone in terms of articulating what the concept means to them. The other sectors associated with infrastructure should also be able to list their basic principles of sustainability.

One of the continuing problems in this country, says Blosser, is that we are very anti-urban; we don't like cities. This is apparent when we consider how suburbs are built - there are no sidewalks. There is also a deep cultural habit of consuming large amounts of resources to maintain our lifestyles. We use a very large percentage of the world's resources. In the long run this is not sustainable. We have always figured a way out of things because of our ingenuity, but we have hit a wall now. But why do something now? Why not wait? How should we do this, and how do we convince people that we need to do something now and pay for it now? This is the issue of discounting.

According to Blosser, certain interesting examples may provide guidance. Oregon has tried to solve some of its development problems at the state level, but it's been a struggle. Sidewalks are required, because it is hoped that this will reduce auto dependency. Also, if people are given the chance, they actually like to walk. But it takes a long time to see the results of these decisions. We are loath to retrofit and the impact of infrastructure requires a long-term perspective. We have to think in terms of 25- to 50-year time frames.

The third participant to comment on the paper was **Vivian Loftness**, one of the authors and the Head of the Department of Architecture at Carnegie-Mellon University. She used many of the seven principles in the paper as a framework for her comments. She began by suggesting that we consider the possibility of launching an American with Disabilities Act civil suit to challenge the issue of lack of sidewalks as an issue of accessibility. Loftness believes that, if we don't create pluralist teams that represent all stakeholders in order to make decisions, we'll continue to make mistakes. We need to create visions and images of multiple options for the future that include life cycle considerations. We are doing a terrible job at life cycle bookkeeping, she said and the results are very high costs associated with sprawl. Oregon has been a great land use experiment, yet some people claim that it has failed, which indicates that we don’t study our actions or get the word out about successes. We need to let people know what they’re missing, and that there are viable alternatives, such as sustainable office buildings.

Loftness also argued that we do a very poor job of pricing things right. For instance, the only thing people really know about their cars is the cost of gasoline and, sometimes, other operating costs. We should talk more about “soft” costs, such as user commuting time. The *Urban Ecology* newsletter reports that U.S. commuting time has increased to over one hour per person. Pluralism is not part of the current agenda, and this is reflected in people's attitudes. For example, if you don't have a car you're out of it. There is a need for more flexibility and multi-mode transportation strategies. We also need to get away from the skyscraper. When buildings are built higher, the floor plates are bigger and there is no light. We’ve embedded our infrastructure in concrete, and someday it will be obsolete. Can we really afford to make our main streets obsolete, and fly to Disney World to re-experience it?

3.4. Industry

The next paper discussed was "The Fractal Theory of Sustainable Infrastructure," by **Lawrence T. Papay** and **Gary L. McAllister**, both from Bechtel. This paper discusses sustainable infrastructure from the perspective of engineering, procurement and construction companies. The main premise is that "issues which create problems with individual infrastructure projects have relevance for generating solutions which apply to sustainable infrastructure on a national or international scale." The authors also argue that "technology is a crucial element in the achievement of sustainability, and technology implementation provides many lessons applicable to the larger goal of sustainable civil infrastructure." The paper sets forth the following criteria for the creation of sustainable infrastructure:

1. On the largest scale of creating sustainable infrastructure, if it is not founded on sound business practices of investment and reward, success is unlikely.

2. Regardless of the size of the venture, the benefits and risks to each of the participants must be clearly defined.

3. For achieving sustainable infrastructure, it will be essential to build a consensus among providers, owners, users, public reviewers and government entities. This is the most important issue. Infrastructure serves multiple objectives to multiple stakeholders.

4. Validation at a modest scale will be an essential part of any large-scale sustainable infrastructure project and will provide the key backing for proponents to argue their case on the largest scale. This deserves the most intense focus possible.

5. Full-scale deployment occurs when the benefits are finally realized. However, those benefits may be difficult to quantify. What makes this difficult is that we believe that the best infrastructure is one where "you pay the cost and I get the benefit."

The paper concludes with a discussion of the Partnership for the Advancement of Infrastructure and its Renewal (PAIR), which the authors describe as an example of a partnership with unique features that would contribute to the strategies listed above. PAIR will bring together leaders in the private sector and non-governmental arenas, to get commitments for research, development, testing, evaluation, and deployment of innovative technologies and practices for the physical infrastructure.

Richard Little, Executive Director of the Board of Infrastructure and the Constructed Environment at the National Academy of Sciences, presented a synopsis of the paper. He began his comments by pointing out that using the concept of fractals in this context is interesting for two reasons. First, in infrastructure, the deeper you go the more detail you will find. Second, the lessons learned can apply at various scales, from one project to another larger project and even to larger systems.

In a discussion of the meaning of sustainable infrastructure, Little commented that the precise definition of the term is unclear. He also pointed out that the President's Council on

Sustainability does not mention infrastructure. One of the main theses of the paper, he said, is that technology provides a way to make infrastructure sustainable. For one thing, technology can improve efficiency and can thus free up financial resources to create more infrastructure or, better still, to do other things that society values. Technology can also be used to determine whether we need to maintain an existing system or make quantum leaps.

According to Little, companies are not monolithic; they do not control technology. He considers the role of the engineer to be an interesting one in the context of sustainable infrastructure. With regard to technology development strategies, he said that the one on consensus is perhaps the most important and that we need to recognize that cost/benefit analysis has often been thought of as "you pay the costs and we benefit." Achieving sustainable infrastructure will require changing this mentality, as there are multiple objectives and multiple stakeholders.

The next participant to comment on this paper was **Charles Trautmann,** Executive Director of Sciencenter, in Ithaca, New York. He said that the paper, which he found very stimulating, deals mainly with how to implement new technologies and could be retitled "Technology, Infrastructure, and Management - How do you teach an old dog new tricks?": it got him thinking about how to think about something differently. He was reminded of the Woody Allen book, *Everything You Know is Wrong*. How do we change people's attitudes about technology when they think they are right?

Trautmann described the Sciencenter's walk-in camera exhibit, where a light passes through a lens and turns images upside down. Children respond to the upside-down image by trying to turn the screen around. So if you think about how people learn, you realize that they take new knowledge, pass it through their existing framework, and generate their new knowledge. Dewey laid the foundation for constructivism in this way.

Trautmann also wondered how we get people to try new things. He described a Sciencenter survey of 25 children and 25 adults designed to determine their knowledge of infrastructure. Where does water come from? Most people (no matter where they came from) said that water comes from wells; many children thought that it came from sewers, from pipes. Where does water end up? Children said sewers; adults said a treatment plant. If you spend $100 on pipe, how much should you spend to maintain it? Young children said $300, children over 12 said $3, and one third of the adults said, "Nothing, it's already there"! This is problematic, because people don't unlearn things easily. So if it is cheaper to build new things, it is harder to think about maintenance. Hence, we should start educating the public at an early stage, when attitudes are forming.

Also commenting on the paper was **Richard Wright,** a former Director of Building and Fire Research Laboratory at the National Institute of Standards and Technology, who said that the aim of his laboratory is to provide measurement technologies to stimulate the development and marketing of improved products and services. He made four points regarding the content of the paper. First, keep in mind that infrastructure involves both private and public facilities and that there is a market element involved. Second, the engineer seeks to do what the owner wants. In order to achieve sustainability, we must educate the owner about it; the contractor/engineer will then follow rapidly. Third, for innovation "demand pull," is more important than "technology

push." We need to help technologists and engineers understand what society needs. Fourth, we need to streamline approvals. An example is the opposition of neighbors to renewal of the Woodrow Wilson Bridge, in the Washington, D.C. metropolitan area.

Gary McAllister also commented on his paper. He began by saying that Richard Little's interpretation of the title was correct and that there wasn't more to the concept of fractals than that. He added that consensus is very important at the local level for the implementation of new technologies. This process then gets carried over to bigger projects. Also, improvements in technology allow us to use resources for other purposes. We need to make better improvements/repairs so we can use our dollars for other things that contribute to sustainability. However, as Charlie Trautmann said, implementation of technology is difficult, and this is an important challenge.

General Discussion of First Set of Papers

These comments were followed by a participatory discussion open to all participants, which was carried out in a Samoan circle. The main points presented are summarized below.

Dick Netzer: It is difficult to persuade and educate people. If you are going to use data, make sure it is right and plausible. Otherwise, your position will be ridiculed. For example, if you are off by a factor of one hundred, opponents can easily show that.

Vivian Loftness: Data should be robust; decisions are not simply driven by the bottom line.

Luis Suarez-Villa: Data should be placed in the context of the countries it is taken from. For example, in Switzerland, environmental education for children is very important and starts at an early age. Also, architects there influence legislation of the built environment. Windows are required in the workplace. Here, developers have the upper hand. Architecture is an elite field here. These values have not been internalized.

Dick Martin: A fundamental premise is that we think we can figure out what we need but we can't, because our needs change. A new example of this is the Hong Kong bank that was originally designed as infrastructure, as a flexible building (by Norman Kloster, an architect, who also designed the Reichstag in Germany). The designers knew that capitalism would change and that the government would change, so they designed a building that could change and be sustainable. It cost Hong Kong $5.2 billion, and it assumed that we don't know the future. They built a sustainable building that could change. Why don't we teach that here? Why don't we understand it? We continue to go on thinking we can predict the world; this is an old view. An old example is how Japanese houses change with time. Whereas in the U.S. every room has a designated function, in Japan you can move the furniture around to change the room. The bedroom becomes the living room, because you can only be in one place at one time. Stuart Harris is the only one who has talked about infrastructure for animals such as elk and fish. This is important because infrastructure is not just about our needs.

Stuart Harris: I am a father, and I think about the quality of life of my children's children. There is currently a lack of focus on a systems view. If you want people to focus on life cycle analysis, you have to teach children about it and expose them to this early on.

Dick Netzer: You can just show them, rather than using bogus statistics.

Michael Replogle: What are the facts? What values do you bring to the assessment of these measures? We should make better use of values. A lot is grounded in values. We can come up with vastly different measurements, depending on the values. A wide range of values is brought out by analysts. Let's discuss values and why different countries invest in infrastructure differently. For example, let's understand why Switzerland and the Netherlands are doing what they are doing. There are very different outcomes.

Amy Helling: People's values do change through better understanding.

Vivian Loftness: We should think about presenting various visions. Pluralism can inspire people, and bicycle riding is an example. But are there common visions we can agree to? Are there ways to communicate this?

Dick Martin: We should think about sustainable factories. For example, take the carpet business. The materials used in some carpets, i.e., those made of polypropylene, are unsustainable, because they are non-biodegradable. This isn't knowledge, it's a belief. The manufacturer believes it is right, so he has set his research facility to do it. You can't convince him through preaching.

Roy Sparrow: The paper by Lowi disappointed me in one respect, and that was in nationalizing something that is inevitably going to be local. People feel locally. People at the local level need to work together to come up with solutions. Solutions will have to emerge locally and education about other people's values is important as well as an understanding of what is and what is not working. We should add to our knowledge base - political scientists should not shy away from localism.

Christine Anderson: Public involvement may drive decisions that are not necessarily the best decisions, either. How do we get values on the table? Public involvement? How do we go from individual preferences to community preferences? You see individual interest in "my 5-acre ranchette" and "my 15-minute commute." But others think people should walk to work and live in high-rises. The local community should be involved in forging a vision that must be responsive to what people are willing to do. In Oregon, one can get community consensus, but individuals won't change their attitudes and behavior but will hold onto their views. They will do what they want to do. We have to get to the attitudes.

Michael Singer: How do we get to innovation and to an innovative way? This can be addressed through the commissioning process and the way funds are secured. We should make innovation a condition of getting a commission. People in power and agency staff need to understand that it is innovation that we want. Think of the team that was put together for the Gowanus Expressway - the agency threw them out because agencies want to work with one firm and the team didn't fit the cookie-cutter approach. It is easier to hire a single contractor than a team.

Nancy Connery: The value of environmental education is a generation away. There has to be long-term investment in colleagues and the next generations. This will have an effect on the professional culture.

Michael Singer: As a result of the transfer station in Phoenix, Arizona, more recycling is taking place, which saves transportation costs. The fact that aesthetics was taken into account means that it is also a place to teach the next generation about recycling. It shows that there was a master plan that sent a message that the landfill should not be covered up. The public is getting a lot of information as a result of this facility.

Presentation of Second Set of Conference Themes: The Arts, the Environment, the Media

3.5. The Arts

The next topic was the role of the arts. First, **Michael Singer**, an artist, described his experiences as an artist in projects where aesthetic considerations were incorporated in project design. Singer began his presentation by saying that he and Nancy Connery, an infrastructure specialist and author of the paper discussed under this topic, have had a seven-year conversation about the role of the artist in infrastructure. He argued that artists should not be brought into projects only after the fact. He then showed a series of slides to demonstrate how artists can be involved in infrastructure building and rebuilding. According to Singer, the artist's technique is to ask questions. He cited the example of planning at Dartmouth College, where the artist invited the architect and not the other way around, which is the way it is usually done.

Singer then showed slides of original work, including those of light wooden structures with geometric patterns in entirely natural areas, and those incorporating stones for pond/basin structures that have a very natural quality. In all cases colors remain natural, beige, grey, brown, black, so that these structures blend easily in a natural environment. In one case, the artist designed a garden with some springs and small rivers. This generated a discussion with engineers who design wastewater treatment units. It was suggested that similar designs could be used to start a new, more localized, approach to water treatment.

Another example presented by Singer was that of the Denver airport. The artist created an outdoor area with gardens incorporated into the built infrastructure. The presence of flowers and birds contrasts with the usual vision of airports as indoor, totally built environments.

Singer then showed the Great Grand Rapid. In this case, the legislation called for the intervention of artists, at different locations, as part of the rehabilitation of a river. Singer took a tour of the area in order to determine what his own location and contribution should be. A planned flood wall caught his attention. It was supposed to be a big concrete structure with no aesthetic merit, but he managed to work in collaboration with the U.S. Corps of Engineers to turn an existing dike into a structural and an artistic/sculptural piece with integrated gardens. The process was interesting to him, as both parties (artist and engineer) had to develop trust and respect for each other. Singer also stressed the importance of being involved at all stages of work. It is not enough to send drawings to a construction company, since the result could be distorted,

especially if it is not well understood. In this case, money was saved by not having to build the flood wall, and the savings will be used to build an access ramp for handicapped people.

Next, Singer talked about a public art project on former wetlands in New Haven. He was surprised to be selected among a group of artists with whom he seemed to have little in common. In fact, the selection committee was interested in his experiences of incorporating artwork into natural scenes. In this particular case, the wetlands needed specific consideration, because of issues of eutrophication and hypoxia. Instead of restoring the site in such a way that past risks to it would be forgotten, Singer used it to tell the story of human intervention with both its detrimental effects (development, nitrification, etc.) and its mitigating effects (preservation and restoration).

An old wastewater treatment plant was also used to illustrate the role an artist can play. In this case, there were plans to replace this old plant. However, by intervening, artists produced a new approach. The building was kept and reused for community education.

Singer also described the time when he was brought to a site to create artwork and noticed a 19th-century barn adjacent to the garden. He learned that mechanical upgrading had been planned and was to result in the construction of an ugly utility structure in one corner of the garden near the barn. He persuaded the client to use money allocated to artwork to construct an underground structure instead. Singer cited this as an example of how an artist's integrated thinking process can benefit a site as a whole.

Another example was a recycling center in Phoenix. In this case, the construction originally planned was very bulky and intimidating. It was designed to accommodate various practical/technical considerations. However, certain other factors had not been taken into account. For example, the dominating wind patterns would have blown potential noxious odors toward an education center, which would have sent an unfortunate message. A team of non-architects/non-engineers was put together to rethink the site plan. The result was an alternative plan that was more attractive and less expensive than the previous one. The new plan also made a point of not covering the nearby landfill as is usually done. Part of the landfill was retained for incorporation into educational programs.

Participants then turned their attention to the paper titled "Fashioning an Ecological View of Civil Infrastructure Systems," by **Nancy Rutledge Connery**, an infrastructure specialist. Connery argues that "an ecological perspective on civil infrastructure systems offers fresh opportunities for cooperative research, diverse collaborations and intuitive approaches to problem solving that have already gained credence in the natural sciences. It may also inject new energy and interest into civil infrastructure systems that will enhance its symbolic value in the public's mind beyond simple utility." Her key points in the paper are these:

1. We need a new mental model of civil infrastructure systems that resonates with the same dynamism and unity that are true of living systems.

2. Building a strong symbolic "bridge to the community" is the most important priority for infrastructure renewal along environmental values.

3. Infrastructure professionals need to broaden their palette of creative approaches to problem solving by inviting a wider range of perspectives to the design table.

4. We need to infuse civil engineering education with a clear understanding of the social, economic, environmental, and aesthetic issues that affect the complex environment of contemporary life.

The first participant to comment on this paper was **Richard Martin**, a professor of architecture at the Georgia Institute of Technology. He began by citing the metaphor of the Bonsai tree. He told of his visit to a Bonsai garden in Palo Alto. When he asked how the gardener kept the Bonsai trees alive, he was told that they have to be sprinkled with water every day, by hand, simulating rain. One of these trees was over 300 years old, which means that someone took the time to sprinkle water over it by hand every day for over 300 years, even as it was being transported from Japan to California. Such an attitude toward sustainability is one that we should associate with infrastructure.

Martin then mentioned several assumptions that lead to a conflict between why and how things are done. They set up how we see and hear issues, and they define our value system:

1. We (humans) think we can solve all problems.
2. We see problems/solutions from a Western perspective.
3. We make every opportunity into a problem. Engineers approach a task by asking, "Okay, what's the problem?"

He also argued that there is a difference between efficiency and effectiveness: doing the thing right versus doing the right thing. In his view art is about effectiveness, about doing the right thing. In order to achieve sustainability, we need to change our point of view. Martin believes that artists can incorporate effectiveness into an efficiency point of view.

David Mammen, President of the Institute of Public Administration, then expressed his thoughts on the Connery paper. He began by saying that as an urban planner he found some of the points to be thought provoking. For example, there are tens of thousands of entities that manage their respective bits of infrastructure. We have 2,000 governments here in the New York City region alone. Mammen wondered how we can make these government entities cooperate in order to address the challenges posed by sustainability. He concluded that much progress has to be made in this area. He was reminded of the watershed agreement, whereby development rights were bought to guarantee a safe water supply for New York City. This involves both planning and governance issues.

Mammen also argued that settlement patterns matter and that we need to focus on managing growth if we want to achieve sustainable human communities. The use of land affects our commute to work, air pollution, and other variables. Although the Phoenix case is a great example, at the end of the day it is still a transfer station and it doesn't solve the problem of sustainability for waste management. Its application to the New York City problem is limited, since partners in sustainable development in New York are several hundred miles away. He

noted that the city still sends its trash to Virginia and suggested that sustainability will require more local-local relationships.

Nancy Connery, commenting on responses to her paper, said that the Phoenix facility does not transform the environment of the city. It is a small step. The Phoenix example symbolizes a challenge to the assumption that because it was a facility nobody cared about it, so it didn't have to be attractive. Although the design of the facility hasn't had an impact on waste, it has served to educate the public, as children come to visit the recycling center as part of their environmental education, and people think about what happens there. They see it as a long-term investment that helped to transform people's thinking. There is also a change in the professional culture. A few years ago, engineers would have been loath to work with the artists, but this helped them to become open to the experience.

Michael Singer, who also responded to these comments, corrected a previous remark. He pointed out that the center in Phoenix is for recycling as well as for transferring solid waste. They have just put in line a plant designed in Germany to recycle - if they recycle instead of just transferring, they can reduce a lot of the costs related to the transport of solid waste. In his design, he was adamant that they not cover up the landfill they created. He wanted to make a point of revealing everything that happens at that site, including the amount of degradation involved, in order to educate the public about it. People are getting a lot of information about it, as it draws a lot of visitors every year. Another value of the facility is that it has helped public works to site other facilities. It is clear that the aesthetics helped them work with communities.

3.6. The Environment

The next paper discussed was “Sustainability and Renewal of Civil Infrastructure: An Environmental Perspective,” by **Michael Oppenheimer** and **Michael Replogle**, both from the Environmental Defense Fund. Their paper discusses the connection between infrastructure and global environmental changes, pointing out that “in this century, emissions from the various components of infrastructure systems, particularly transportation and electricity generation, are not only transported worldwide by atmospheric and oceanic currents in significant quantity, but they now are capable of determining to an important degree the functioning of nature's own ‘infrastructure systems,’ e.g., the global climate and ozone layer.” They go on to say: “Infrastructure systems are driving the environmental phenomenon known as global change, and in turn, global change presents a large and unprecedented challenge to the sustainability of infrastructure systems.”

In their paper, the authors examine this relationship between infrastructure and global environmental change by asking the following questions:

1. What changes are infrastructure systems projected to cause that could undermine their own sustainability?

2. How can infrastructure be made resilient in the face of global change?

3. How can infrastructure be renewed so as to minimize its contribution to global climate change?

4. Given the long planning and implementation horizon for most infrastructure systems and the uncertainty entailed in projecting future global change, how is it possible at all to sensibly plan future infrastructure?

The authors conclude by stating that "in the future, a two-fold problem for infrastructure planning will arise due to anticipated, as well as unpredictable, changes in the global climate, brought about in part by use of the infrastructure systems themselves. History no longer provides a reliable guide to future climate conditions, and the time scale for learning may be comparable to both the time scale of climate change and the time scale of infrastructure planning."

Christine Anderson, Director of Public Works for the City of Eugene, Oregon, was the first participant to comment on this paper. She argued that there are two approaches to looking at the problem of sustainability. One is to look at external driving forces such as energy conversion and global warming; the other is to look at current behavioral trends in areas like transportation. According to Anderson, the focus on pricing is not the underpinning element. Though it can have a marginal effect, behavior is more important. Cultural values such as personal freedoms and behavior like our insatiable appetite for consumption are the fundamental issues that we need to focus on in order to address the issue of sustainability.

Dick Netzer, a professor at NYU's Wagner School of Public Service, summarized the paper as examining what kinds of measures can be taken. He wondered whether the real question concerns protection, or the things that governments should do. He argued that it may well be that we need to get government out of the way and let the private sector in. An example would be for government to refrain from subsidized insurance and allow prices to rise so that use patterns change. For instance, if New York's airports were privatized, landing fees would be differentiated to reflect problems at La Guardia.

Netzer also asked whether the problem was one of preservation or mitigation. He pointed out that since 44% of all greenhouse gas emissions come from neither transportation nor energy utilities, one obvious source is homeowner's use of space heating units and individual furnaces. According to Netzer, this is a hard target for policy planners (no one wants to take on homeowners), but not necessarily more difficult than transportation. Congestion pricing, one of the solutions posed for the transportation sector, is easy to talk about but difficult to implement. Moreover, a few of the most eminent urban economists believe the right policy would be to implement a huge increase in motor fuel taxes and not necessarily congestion fees. Their arguments are persuasive.

The third participant to comment on this paper was **Al Wallace**, a professor at Rensselaer Polytechnic Institute. He argued that we now have very sophisticated models and wondered what we would do if we had a good complex model for problems such as climate change. We are beginning to build some intense models in this area. Models of biodiversity are being funded, and networks of models are being developed. We also have to support competing models and then look for robustness. In addition, Wallace wondered what would happen if we had accurate

models of human systems, arguing that, although they are further down the line, a lot is being done with cognitive models. He said we are beginning to model societies and this may be useful in thinking about decentralized decision-making. He raised the question of how to find common ground between the desire for decentralized decision-making and the existence of networked collective decisions. Wallace also talked about the difference between a right and a privilege. He believes that we are not taking advantage of the opportunities presented by recent developments in telecommunications and called for basic research on these issues.

The authors were also asked to comment on their paper. **Michael Oppenheimer** started by saying that he was tempted to think that the solution to the points raised in the paper is for infrastructure to become a major actor in everyone's environmental future. Infrastructure is not just something you just build and walk away from. Its consequences rebound. The parts that cause the problem and those that solve the problem are different. He argued that infrastructure can be made more resilient and flexible as the future becomes more unpredictable, and it can also be made to have less environmental impact. He sees the time scale problem, the fact that it takes a long time for people to learn and change their behavior, as the most important issue. People don't understand where things come from, for example, electricity. People think it comes from the wall, instead of the power plant. Industry does not take climate change into account in its planning. We may need a time horizon of 30-40 years to change behavior. Moreover, history provides no reasonable context anymore for what is happening to global environmental services. Models will get better, but it will take decades; it won't happen right away.

Michael Replogle suggested that infrastructure is a form of embedded intelligence. It is a way of telling people how to behave. It creates theater space. It's essentially a form of DNA that is carried well beyond our own lifetime to influence behavior. It is deeply embedded and an expression of cultural values. He too mentioned that the time horizon is particularly troubling, given things like climate change. The rapid change from industrialization to information means that new sets of demands for what our infrastructure should do are increasing. Replogle also argued that there is a disconnect between government structures and management structures and the new demands we are making on infrastructure. We built the greatest highway system in the world, and now we are coming to terms with the implications of that infrastructure. We developed the highway system as an extension of our society but didn't consider what an increase in mobility would mean. With prices falling, we increased mobility. There is a time lag problem that we need to manage. The automobile, which is considered the ideal form of transportation, has become its own worst enemy, because we can't provide any more infrastructure for it. This is analogous to tourism, because it destroys the amenity it seeks. So we need to embed the intelligence in the infrastructure: What are the costs? How do they vary in time and space? We are in danger of losing the fundamental right to walk and of losing the expectation that we ought to be able to walk. Without the choice, we lose the information that we can walk, and we substitute damages. In short, we are struggling with a paradigm shift of using infrastructure and the choices that we have. We have the opportunity to manage with new information technologies.

3.7. The Media

Rather than discussing the role or perspective of the media per se with respect to infrastructure and sustainability, participants in various media professions expressed their particular views of infrastructure and sustainability.

The last paper discussed was “Bicycle Infrastructure for the 2030s,” by **Bill Nye**, television’s “The Science Guy.” Nye argues that if, as a society, we take the necessary steps to simplify bicycle commuting, “by the year 2030, we could have a significant portion of our workers, say 10%, getting to work in human powered vehicles.” He believes that the biggest limitation to this mode of transportation is usually the infrastructure in which cyclists are constrained to travel and that “it is possible to pass laws that ensure that bike facilities are incorporated in all new roadway construction and, where possible, all roadway refurbishment or expansion.” Among the other problems that need to be solved in order to make bicycling a better option, Nye mentions the need for riders to be able to shower when they get to work and the need to develop warmer bikes so that riders can bicycle in cold weather.

The first participant to comment on Nye's paper was **Al Grant,** a consultant to ASCE. He first identified the impediments to bicycling. First is the issue of gaining sufficient speed to make the ride predictable. This requires new roadway construction and expansion to serve bicyclists' needs. Second, clean riders and clean clothes are needed. This means an increase in laundry services and in the availability of showering services. The latter could be provided by physical fitness facilities in the workplace. The third impediment is weather. Bike designers and manufacturers should work on self-enclosed human powered vehicles. If bicycling were to increase, we could save energy and slow climate change. In addition, bike commuting can improve the quality of life; it could well be worth the investment.

The other participant to comment on this paper was **Amy Helling**, Assistant Professor at Georgia State University's Department of Public Administration and Urban Studies. She began by posing the following questions: What is the underlying goal of promoting bike commuting? Are we leaping too far ahead? What is the ultimate purpose? She believes that some of the goals of promoting bicycling are saving fossil fuels, enhancing physical fitness, and increasing the quality of life. A corollary question is: Who can you get to support this goal? We have a sub-population that is well organized. Citizens are not that well prepared to participate in infrastructure decisions but this is not true in the case of bicyclists. When a group has an achievable and desirable goal, its members get involved.

Helling also asked: What are the consequences of higher travel speeds? Auto speeds have had undesirable effects. Will bikes have similar effects? Higher travel speeds have consequences for a city's economy, for example, greater separation. Hence, greater speed in bicycle travel may also create some of these problems. Are work commutes the most valuable place to put our emphasis? Other trips, where riders can be dressed more casually may be a better target. And work trips are made in darkness, which does not lend itself to bikes. Helling believes that non-commuting trips suggest other proposals. And what are the safety issues? Although bicycle speeds are lower, there are still a number of pedestrian/bicycle issues related to safety that need to be addressed.

General Discussion of Second Set of Papers

As with the first set of papers, all participants were then asked to comment and discuss their reactions in a Samoan circle. The main points expressed are summarized below.

Alternative Modes of Travel: Automobiles and Bicycles

Christine Anderson: The Nye paper could have been written in 1973 in Eugene, Oregon. Things are not working that way; the Oregon example is not perfect. We have a population that is not so large that it cannot change. We have a population that is motivated. So why is it not working there? We can't make large shifts. Why is it important? Capacity at peak hours is still a quality of life issue. The climate generally supports year round cycling. We achieved a 6% bicycle commuter increase, but it is not growing anymore. Why are people not doing it?

Michael Replogle: There are factors that go beyond bicycle infrastructure. The cost of travel in a car is cheap. Car insurance, access, etc., are all cheap. The marginal cost of keeping a car once you have bought it is zero. Also, general purpose taxes go to roads. There is free parking, which is a huge cost to society. Those costs are buried in your paycheck. Hidden incentives tell you to use the car. Land uses are separated, and there is $10 billion of auto advertising. Moreover, the car is the way you assert status and protect your family from danger. All these factors make it difficult to replicate the automobile.

Nancy Connery: Commuting is actually going down as a percentage of travel. This includes linked trips and commutes to work.

Michael Oppenheimer: The bicycle is not a key transportation mode. It is symbolic. The transportation system has driven everything out except the automobile. Unfortunately, the automobile is the only practical alternative. For most people there is nothing else. Is the current system hopeless because it is so packed with hidden subsidies?

Tokue Shibata: The cost of gasoline is a major factor. In China ten years ago, there were floods of bicycles. City planning was based on that. Now the central city is decaying, and development is occuring further and further away. Bill Nye should go to China to support his argument about the bicycle! In San Francisco, people may oppose the use of bikes because of steep slopes, but small battery systems could make it easier. There are other options as well, such as collapsible bikes and tricycles to carry bags and children. Different assumptions make for different stories. In Japan after the mid-19th century, we adopted a policy of isolation. There was no importation and we had few resources, so we had no garbage. In 1945 General McArthur came in, and now we have too much consumption; now we are more Americanized than New York.

John Falcocchio: The issue of benefits and costs has not been discussed. The benefits of auto travel are far outweighing the costs. People are focusing on long-term needs, but the public, and especially decision makers, are focusing on the short term. People decide based on what they expect to get out of it. Automobiles have opened up many opportunities. Technology has driven the benefits, but now we are here talking about how undesirable things have become; our way of life is being rejected. Sprawl is the result of policies that we helped to institute. For example, it

is expensive to get permits to build in inner cities. Cities are penalized that could absorb more development. Environmental laws and considerations are making it difficult to build in cities.

Michael Oppenheimer: To eliminate dependence on the car would mean entirely re-inventing America, and that won't happen, at least not soon. Instead, we will build a car that has zero emissions. Cars are part of the transportation picture. However, a zero-emission car won't solve the congestion issue. The critical point is that the more diverse the transportation system, the more choices are out there.

Luis Suarez-Villa: Look at travel behavior, transport modes and the links and connections between them. In the Netherlands, bikes are used a lot. There is a fantastic rail system. There is much local travel, so you can use a bike and you can put the bike on the train. Here there are cars. People don't have that choice in many situations. The car is the choice. Most people feel safer in a car, and bike accidents are a serious concern. There is not enough choice out there. The choice is a rational one. Think of the inconveniences of helmets, etc.

Tom O'Rourke: The bicycle could be an allegory. Bill Nye is asking us this: If we wanted to achieve sustainability, what would need to occur? The phrase "quality of life" keeps coming up. Sustainability is at odds with the American Dream. Sustainability used to mean that if you increased your standard of living, your quality of life would improve. But in the 1970s and 1980s there was change, and an increase in the standard of living no longer meant an improvement in the quality of life. There was a major paradigm shift. What do we mean when we speak of the quality of life? Does this mean changes in infrastructure?

Dick Schuler: Why did Bill Nye choose the bicycle instead of walking? Are there values and human aspirations revealed by that choice? Observation - Schuler's law: Urban highway systems will be used until they are congested. What does this imply about society's ultimate satisfaction?

Daniel Davis: How do you persuade people to change from cars to bikes? There are public will issues. Is there a way to get the public to have the will?

<u>The Role of Values in Shaping Infrastructure Choice</u>

Rae Zimmerman: There is a clash between more information, and values. Where do values fit in? How do we shape information?

Nancy Connery: The word "value" is key. "Values" is a vague word, but it is the first time at an infrastructure forum that values are being talked about. It is a tricky subject, but we are talking about it. In talking about values in various ways, we can help make the small shifts and begin to shape something else.

Michael Singer: The community begins to expect more. Usually we hear that we can only afford vanilla. The more the community voice comes through and understands the values, the more we realize that chocolate does not have to cost that much more. Innovative design can reduce costs.

Michael Replogle: We don't measure quality of life issues. For example, walking to school. How many of you walked to school as children? How many of your children walk to school? How much time do you spend driving, and what are the costs of that? Time saved or expended is stressed, but we don't put a value on that.

Jennifer Wolch: I am all for value questions, but it suggests that individuals and behavior have to be changed. What about institutional structures? Consumption is the question. It increases the standard of living but doesn't necessarily lead to a better quality of life.

Infrastructure Definitions in Light of Sustainability

The discussion then turned to the matter of definitions of infrastructure, sustainability and the relationship between these two terms. Here are some of the main points:

1.Infrastructure as Public Works:

Infrastructure should be defined, and public works and civil infrastructure are nice names for it.

We can't deal with infrastructure if we just think of public works. The term does not capture everything.

2.Scale: Project vs. Systems Perspectives for a Definition of Infrastructure:

Having a discussion only at the project level doesn't work; you need a system level. If we don't have a process, it becomes a roadblock in order to stop projects. People will bring their own biases to the table.

People think of projects or facilities when they think of infrastructure, but there are systems that provide services and projects that relate to other things. You've got to worry about a process in which knowledge and values get injected into a system.

There are different scales of analysis, which we have to recognize: micro levels and macro levels.

We need to think about the scope. It's global. We can't keep thinking locally anymore.

3.Infrastructure as Assets:

Infrastructure is a system of physical assets that link people with services and resources from community goals. We can define assets - roads, etc. Most people have no concept of how things operate or that they are even there.

Infrastructure is not just physical assets. We need to think in broader terms.

Federal allocation of resources for state and local governments is also part of the infrastructure, and we have to be cognizant of that.

4.The Concept of Sustainability in the Definition of Infrastructure:

“Sustainability” may be a word used by the opposition, that is, by people trying to oppose projects. But sustainability could be both proactive and oppositional.

Technology sustains our lifestyle – Some people don't like the word “sustainability” because it doesn't have the connotation of change, and we live under constantly changing conditions.

Sustainability could be defined as the process of harmonizing community goals. There are lots of communities with different goals.

5.Infrastructure Definition as a Function of Process:

Page 4 of William Petak's paper contains a nice definition of infrastructure. We could create a scorecard - a measurable set of standards. The political process will then decide if it needs to be done or not.

The decision-making process affects the way infrastructure develops.

Processes exist within constitutional structures, so the constitutional framework has to provide guidelines for choice of projects. But we can't just leave it to process.

We should think about the approach: local governments are conservative - to them sustainability is a way to make things better. This needs to be clarified.

We need a more pluralistic definition of community.

Plurality of development is crucial. Why are we building new infrastructure in every project? This has to be considered up front.

6.Necessity for the Definition:

Educated voters are going to have a hard time understanding this. If we can't put our thoughts in concise definitions we'll never get anywhere.

7.General Comments:

Infrastructure is both a social service system and an engineering system. There are engineering solutions and social and environmental implications associated with infrastructure.

The knowledge that's required to address issues of infrastructure and sustainability is multi-disciplinary, and current education doesn't provide it.

Authors' Reflections

On the second day, the authors were asked to reflect on what they would add or change in their papers after having attended the conference and having heard the other participants' comments and discussions. The authors' comments are summarized as follows:

Vivian Loftness: I would focus more on communication. There is an ongoing effort to map out two or three futures. I think the participation process is hampered by the fact that people don't know what the options are. Good solutions are not being replicated, because people do not know about them. Also, we need life cycle information to help people argue for things that are not just cheap alternatives. We need data on the financial, political, and social costs of infrastructure projects.

Greg McAllister: If I had to do it over, I would say that we need to focus more on the practical side of what ICIS can do and to use data that is out there on things that have worked versus things that have not. I would take a more pragmatic approach.

Stuart Harris: I would probably write on a more global scale. I would look at the problem set and the value set differently. I would also pay more attention to the distribution of resources, services, and goods. The responsibility of the infrastructure problem is mind-boggling, and the focus is all over the place. We have to think about personal, national, and global responsibilities. The way to address this is to set up the goals up front and think about what we are trying to achieve. We need to teach children about long-term goals. We also have to think carefully about the impacts of infrastructure and about what we want to invest in. Should we choose to invest in solar energy? We are talking at the level of extinction here.

Nancy Connery: I understood my paper was a work in progress. Built systems are more about the way we live and what we value. I'm still convinced that the metaphor of built systems is not just a list of things but that by expanding the model we can bring more liveliness and emotion to the discussion about what needs to be done. The goals need to be more concrete. I dismissed sustainability, because it doesn't seem to get anywhere, but this doesn't have to be the case. For example, there is a book by Paul Hawken, *The Ecology of Commerce,* and he makes the argument that we can reduce energy and resource consumption by 80%. This does not have to be achieved by pounding people, but through markets. The public has to be given a broader array of choices. I feel strongly that I need to explain this better.

Ted Lowi: I would stress the need for the rule of law to govern every project. Public works is paradigmatic, and what I would make more explicit is that laws should be more negative in the sense of things that can't be done. We need more explicit rules. Cities are inherently conservative, and they try to maintain existing values. I would also be more explicit about the transparency about who benefits. EIS should be revised so that it's more transparent about who benefits, i.e., land values and how they benefit from infrastructure projects. We don't know where we are going, but there are some roads that are better than others, given where we are.

Bill Nye: He emphasized, in response to O'Rourke's earlier comment, that his paper is about what it is about. It is not an allegory for anything. It is a specific proposal to improve life for

everyone. Energy is astonishingly cheap now, and this presents an opportunity to provide an alternative by incrementally engineering things to promote human powered vehicles. Leaders need to ride bikes. There are problems for bicycle riding like broken glass, so the streets need to be clean. We can also think about pedal powered rickshaws and bike messengers. There is a huge opportunity for those that make better bicycles.

4. Discussion of Critical Issues Raised at the Conference

One of the main goals of the conference was to identify and discuss the most important issues related to civil infrastructure and sustainable development that the papers had suggested.

Two topics were discussed in an open forum: 1) Defining sustainability and infrastructure; and 2) Communicating with the public.

After the open forum, participants engaged in a brainstorming session to select four other topics for detailed discussion. They were then divided into four breakout groups, each of which discussed one topic and presented the results to the full group. The topics were: 1) Teaching and learning; 2) The project approval process; 3) Hazard management; and 4) Techno-diversity and its relevance to sustainability. The results of the discussions of all six topics (four in break out sessions and two in the plenary session) are presented in this section of the report. Implications for an ICIS agenda were touched on in these breakout sessions; however, the more detailed discussion of this theme came afterwards, and is presented in Section 5.

4.1. Defining Sustainability and Infrastructure

Introductory Remarks

The discussion about defining sustainability and infrastructure ranged from trying to come up with working definitions of the two terms to describing the process of participation that should be used in arriving at these definitions. Some of the participants felt the idea of defining these concepts in a forum such as the conference conflicts with sustainability as a process, because it highlights the divide between technical specialists and everyone else. It was argued that nonspecialists' ideas about these concepts should not be excluded and that much can be accomplished by allowing people to participate in the process in a way that is not too structured. Other participants felt that institutions lead the way in which technology and infrastructure evolve and that their role is vital.

The question of whether sustainability and infrastructure can be defined differently was raised. The group felt that such definitions change over time. This is not necessarily the case with other concepts. It is, however, for infrastructure systems, where people's expectations change, and certainly for sustainability, where society is learning how to deal with very complicated issues associated with global changes such as global climate change and loss of biodiversity. The group said that in the area of sustainability we really are amateurs – when professionals move slightly from their professions, they become amateurs. Although it may be easy to define sustainability for a particular project, moving to a larger scale makes it far more difficult. However, participants felt that defining it at the project level is inadequate, because considerations of sustainability at this level come too late. They have to be incorporated at the system level.

Sustainability

The difficulties in defining the concept of sustainability are compounded by the fact that local governments are inherently conservative and planning is conservative. Hence, sustainability has

to be defined in that context. Some participants argued that a definition of sustainability should consider what the community elders and social builders are thinking about. Still others mentioned that they don't like the word "sustainability" because it does not incorporate the concept of change. To them the word is preservationist, and in order to achieve sustainability we need to change many things.

The group also mentioned that sustainability can be thought of as the process of harmonizing community goals. Different communities have different goals, and reconciling them is important. It was felt that a broader, more pluralistic definition of community is also needed to achieve this, since the traditional definition is too anthropocentric. Hence, if environmental sustainability is to be achieved, a broader definition of community that encompasses environmental goals should be used.

Infrastructure

One suggestion was to use the traditional definition of "infrastructure," which includes or is the same as "public works." Such a definition could then be narrowed down to strategically located public works. Other members of the group believed that it is inaccurate to think of infrastructure in terms in public works. First, this limits its scope. Second, some infrastructure is public and some is private – there is actually a continuum from one extreme to the other. Third, public works is too limited, because it does not include power and telecommunications, which are not public. Fourth, the word "infrastructure" is a little better than public works, since "infra" means "below" (like "infrared") or "structures underneath." Fifth, defining infrastructure at the project level is too restrictive. As with sustainability, however, when moving to a scale above that of the project level, defining the term becomes even harder. The George Washington Bridge in New York City is an example. The Port Authority of New York and New Jersey has a methodology of regular maintenance. It was pointed out that such methods are intriguing at the local level, because people think in terms of a project or facility. However, infrastructure is really about systems and relationships, which are often overlooked in policies that affect infrastructure, such as maintenance. It was argued that projects and systems must relate to each other if they are to meet society's performance expectations. At a more basic level, it was also suggested that we consider why infrastructure is produced to begin with. The reason is that it supports capital accumulation, and this must be considered when discussing the sustainability of infrastructure systems.

Infrastructure can therefore be thought of as a system of physical assets that support community goals, at a local, regional or global level. These physical assets can be defined more easily. They include transportation, water supply, wastewater treatment, energy production, and others. However, most of the public and infrastructure beneficiaries have no concept of how these systems work, and sometimes they don't even know that they are there. Hence, the group felt that in order to move toward sustainable civil infrastructure systems there should be a greater appreciation of how these systems operate. If people understood this better, they would be better owners and would manage resources better. Linking people with the services they use is thus critical. To do this, it is necessary to get away from projects and to think in terms of systems.

Other participants felt that defining infrastructure as a system of physical assets is too narrow and concentrates too much on the physical side of things. They cited factors such as the educational infrastructure, or knowledge, and communications, which call for a broader definition. Physical assets are the pieces that wear out, but there are also services and intangibles that go into the system.

The group also discussed how to communicate these often technical definitions to the public. First of all, clear words are essential. The public does not talk the way specialists talk. One way to look at civil infrastructure is to describe whether it will continue to degrade the environment. Ideas need to be put in very concise terms, and definitions need to be as simple as possible. Although the definitions of these concepts do not need to be as precise as those found in a dictionary, they should allow for public discussions. Some participants felt that a process is needed for discussions about definitions that allows for individual biases to be included but not to distort the results.

Infrastructure and Sustainability

A discussion of the relationship between infrastructure and sustainability included the question of how to sustain an operating system that is managed and planned by different entities. Coordination among agencies is difficult, because oftentimes they do not exchange information and/or technology. The systems nature of infrastructure, and its resulting problems, led some members of the group to argue that the process of project approval is something that society should pay attention to, because knowledge and values get injected into a system that is supplying service to those who use it. To the extent that users regard issues of sustainability as important to them, these issues may be reflected in infrastructure projects.

The group also felt that linking civil infrastructure systems to ideas of sustainability is challenging because engineering decisions have to be embedded in a social environment that responds to politics and economics. Sustainability would require decision-makers to present the social and environmental implications of their actions. Engineers have an important role: they are responsible for making things that people want and that enhance quality of life. Accomplishing this task, however, requires a multi-disciplinary team. Hence, sustainable civil infrastructure systems will require a major shift in the way they are planned for and will require much more collaborative work. The group felt that education systems have not yet reached this level in terms of teaching necessary skills to future generations of engineers. Some participants said it would be helpful for professionals to have process standards that should lead to a multiplicity of solutions. Another challenge to sustainability is the potential conflict between the traditional single best solution that is sometimes offered by engineers and the multiple possibilities/solutions that should be discussed by stakeholders.

Achieving sustainable civil infrastructure systems will also require defining the scope of projects. Although most projects are regarded as local, or sometimes regional, most of them are actually global in scope. Moreover, all services are global. Natural resources are limited, and an attempt should be made to determine the impact of where they are being taken and where they are going. This would allow for a proper accounting of the impact of civil infrastructure systems. The people who are affected by resource extraction and transportation should have a say in

project planning and in defining sustainable infrastructure. These discussions have to be on a global level, or at the every least on a watershed basis.

However, some of the participants felt that such broad definitions are of little practical use and that if used, the group could spend a year discussing them and eventually decide to include everything. One thing the group felt strongly about was that environmental considerations should not be left to the end. In order to ensure this, a pluralist process that results in multiple solutions is necessary. Questions such as why a new infrastructure is being built should always be asked up front, and the traditional expansionist mentality should be questioned and changed where necessary.

The group also discussed two broad areas where ICIS could make important contributions. The first is to come up with a methodology to break down projects and systems into measurable components of sustainability, such as energy use, materials, and others. This would allow decision makers to be informed and would move things in a more sustainable direction. In short, ICIS could develop a set of measurable standards. The second is to communicate the concept of sustainable infrastructure to the public. This is discussed in more detail below.

4.2. Communicating with the Public

According to the participants, an important area for ICIS was to effectively communicate ideas about sustainable civil infrastructure to the public. The key to this is to think carefully about what should be communicated and why, and whether the target should be the public or the decision makers. The public is the ultimate owner and user of civil infrastructure systems; the group agreed that if the public remains ignorant, it will continue to look at infrastructure as an entitlement. There are good examples of what can happen when the public becomes informed about issues. One of them is the case of environmental awareness. Children have been educated on environmental matters, and they need to be similarly educated about civil infrastructure. There is a need to elevate the level of awareness and understanding of infrastructure.

One participant felt that by the time children enter the 6th grade they can already make a lot of decisions by themselves – adult decisions – so it makes sense to focus on them as a target audience. This means that the vocabulary should be adapted to this level as well. It was also observed that in current discussions about sustainability and civil infrastructure there is too much academic jargon, and that it is not comprehended even by educated voters. This means there is a real need for discipline in choosing vocabulary.

Trautmann pointed out that a younger target audience will serve the mission of this project better. 6th grade is too late – minds are made up and focused on other things (opposite sex, sports, video games). He would shoot for 2nd-5th grade.

The group also said it is necessary to think about what is public interest and collective interest; information was deemed insufficient in this area. It was also noted that it is necessary to understand what kinds of information can better inform citizens, and who should be involved in the decision-making process. A closer analysis of good examples of public involvement was suggested. For example, it would be helpful to know what leads the public to embrace recycling.

Such examples could be contrasted with other areas, such as global climate change, where little public action is taking place.

Another reason why communicating with the public is vital in the opinion of the participants is that it allows people to learn about the opportunities they have missed by taking a certain route. Communication can capture the choices and show examples of available and potential alternatives. Communication is also important because the public can be viewed as voters who sometimes adopt surprising positions and who know what they want.

Communicating these ideas to the public was also viewed by the group as a means of getting the directors of public works projects to understand what the public wants. It was agreed that, to accomplish this, better information is needed. This need is compounded by the fact that in the United States there are thousands of small-scale decision makers, and decisions are made individually. The Environmental Impact Statement (EIS) is one mechanism that provides leads for people who want to learn, think, and intervene in discussions about civil infrastructure systems. There is a need for other mechanisms that allow for this kind of participation and exchange of ideas. Some participants felt that the EIS process, although helpful, should be revised if it is to contribute to sustainable civil infrastructure systems: EIS was designed with a project focus and fails to take a systems approach into consideration.

Some participants said that broadening the scope of a process such as EIS should be viewed with caution. An analogy was made with comprehensive planning, which didn't work, because it ignored the social aspects. Sustainability, it was suggested, could be interpreted as looking at the next step and what happens after a project is finished. It should not be like the city of Brasilia, where all the steps are worked out. Other members felt the analogy was weak: Brasilia is not necessarily a good example of planning. A better one is the state of Oregon, where all the social, environmental, and technical implications are discussed. Brasilia was developed solely by architects. The argument was made that a plural team is needed and that all the broad issues have to addressed. The vision should not be something in concrete but should be more of a skeletal framework.

Some participants went on to maintain that low-level planning is better than comprehensive planning and that a systems approach can be overwhelming. Elected officials, policymakers, and others are not used to thinking on that scale. Others felt that this is not necessarily the case: the Beltway was cited as an example of what could be interpreted as comprehensive planning with dramatic consequences and the creation of comprehensive networks. It was argued that networks can be built incrementally, but that without a clear vision the process doesn't work. In order to make a comprehensive planning approach successful, a multi-experienced team that is committed to a plan is necessary.

On a related topic, participants noted that there are significant variations around the country regarding the process of decision-making. These variations are due to public policy, which is influenced by the behavior of people in charge. The ethics and the level of awareness differ from place to place; this is one reason why ICIS's responsibilities should include educating the public. This means also identifying which segments need educating. There are places where the public is involved in projects. For example, the West Coast has a much richer process than the East Coast.

This is partly driven by public policy, but also by a notion of the process itself, and of who ought to be invited, and leaders make certain that the people have the information. They look at it as part of their responsibility to educate and to ensure inclusion. Communicating this point of view is part of what ICIS should do.

Also discussed was the role of communication in getting the public to learn and participate in forums such as discussions of EIS. The use of the Internet was mentioned as an important tool; more could be done in this area. With respect to the role of regulations, the law now requires only paper information and public meetings. New tools such as the Internet should be added to the menu of options.

Recommendations for ICIS included analyzing areas where there is lack of information and identifying ways to help citizens make better decisions and increase their participation. ICIS should try to understand the knowledge base for a project or system, who is involved, and the role of the law in the process. In short, ICIS needs to identify successful efforts and distill them into processes that can be applied elsewhere or into lessons to be learned. ICIS should be a service organization serving the public, not telling the public what it wants.

4.3. Teaching and Learning

This breakout session began with a discussion of the broad problems associated with infrastructure. The more important ones were considered to be these: the loss of communities; the loss of public connection to infrastructure; the lack of knowledge about infrastructure; and the lack of understanding of the relationship between individuals and infrastructure systems. These problems were considered from a sustainability perspective. The group felt that changes in the education system could be implemented to address these problems and modify current civil infrastructure projects and trends to achieve sustainable development patterns. The main changes discussed were the following: sustainability and infrastructure education in the K-12 system; strengthening federal and industry support for education in these areas; and adding new skills to traditional engineering education curricula. The group also noted that in order to ascertain the right changes in values, communities need to think about their medium- and long-term goals.

K-12 Education

According to the group, changes are needed in the K-12 education system because it is essential to instill sustainability values at an early age. This would allow students to learn more about their relationship to the ecosystem they live in, the impacts of their actions and their relationship to infrastructure systems. Future generations could then better play the role of educated voters. Values can be instilled through observations and activities. Activities entail allowing children to discover things for themselves by getting involved in model building and projects. Lessons could be drawn from the experience of Native Americans, who learn to respect their past and see themselves as part of the future.

The following skills and values should be incorporated into the K-12 education system. First, teach children what is local and what the units of the local ecosystem are. This would help future generations become attuned to the impacts of their decisions and manage their resources better.

Second, teach trade-off thinking. Adults must change their mentality from a bias of present consumption to one that considers sustainability as a goal in itself. Third, consider the social dimension. Children need to learn more about equity issues and the social impact of civil infrastructure projects. Finally, explain risks: most children have a poor understanding of the risks involved with car ownership and other factors that may influence their livelihoods and the sustainability of their communities.

In a discussion of the complexities of changing behaviors and introducing new values to society, the group agreed that lessons from other efforts to instill values would be helpful. For example, sex education has met with different rates of success in different contexts. Also mentioned was the point that changes in values are best achieved when children and young adults teach each other.

Government and Industry Support for Education

This discussion resulted in four main suggestions. The first was to allocate about 1% of the total cost of public works projects to educating the public about infrastructure and how it affects their lives and communities. This should also include education about sustainability and how infrastructure contributes to or affects sustainable development.

The second suggestion was for federal and state permit processes, such as the National Pollutant Discharge Elimination System (NPDES) storm-water permit system, to include educational requirements for applicants. Requirements would include teaching users and communities about the infrastructure systems they manage and their impacts on the sustainability of communities.

The third suggestion was to require or encourage volunteer efforts to educate communities and individuals about infrastructure and sustainable development. Volunteering could be at various levels and could be a precondition for obtaining funds or other kinds of support from government or industry.

A final suggestion was for agencies such as the National Science Foundation to promote curriculum development through institutes like ICIS. New curricula at different levels of the education system should include aspects of civil infrastructure and sustainable development. For example in Eugene, Oregon, the school curriculum includes issues associated with storm water planning.

Other Considerations

The group also considered changes needed in engineering education. A major issue concerns the skills that engineers are taught in higher education institutions. Some members of the group expressed concern that potentially strong leaders self-select out of practicing engineering.

In addition to the skills currently imparted by institutions of higher education, these were considered necessary: the ability to listen to others and work in multi-disciplinary environments, and an understanding of design and operation for sustainable development. Group members agreed, however, that the time constraints of an engineering education make it a real challenge to

adequately incorporate additional skills in what is generally considered difficult and specialized training.

4.4. The Project Approval Process

The main conclusion of this breakout session was that the current civil infrastructure project approval process takes a long time, is expensive, and often produces poor results. Among the causes are a lack of early stakeholder involvement in project design and planning, a lack of information in communities about alternatives, a lack of information about the secondary impacts of infrastructure, and the fact that the process itself has become an end rather than a means to achieving a specific goal.

Streamlining the Approval Process

One focus for the group was how to streamline the process without closing options for different stakeholders to participate in project design and planning. An example cited was the environmental permit process, which allows different stakeholders to participate but is often seen as a costly process that allows even small interest groups to stop projects. This was contrasted with the Robert Moses era, when stakeholders did not participate in the project approval process, but many important and necessary infrastructure projects were built. Since then, little has been accomplished. One reason is the lack of trust and consensus among interest groups. As a result, much time and money are spent on legal action and consultants. These costs could be reduced if agencies and managers discussed their projects with communities at the earliest stages of design and planning.

Institutional Mechanisms for Stakeholder Participation

The group also addressed the lack of institutional mechanisms that would allow for stakeholder participation and enable agencies to speak to one another and to consider the incentives for neighbors to accept or reject projects. Here “neighbors” refers not only to the people affected by infrastructure projects but also to other agencies providing infrastructure services. The group recommended studying models of conflict resolution and stakeholder participation in other countries and contexts and examining their feasibility in this country.

Leadership

The main problems associated with leadership involve term limits, which provide the wrong incentives and restrict the power of agency staff. With respect to the latter, technical people are often not heard in the process, and they are often fearful of expressing their views in a process that is dominated by lawyers.

Cost Implications

The current project approval process and the lack of consensus as projects are implemented often results in costs which amount to 6-8% or more of the total project cost. This means that there are

many people whose livelihoods depend on the project approval process. The group felt that if the current project approval process is to be changed, this factor must be considered.

Synopsis

The group concluded by producing a list of issues for ICIS to address:

- How to ensure the early involvement of stakeholders in the process
- Better understanding of impacts of infrastructure projects (2^{nd} and 3^{rd} order impacts)
- How to incorporate constructive incentives in the process: Are there any? If so, what are the trade-offs between efficiency and equity?
- How to reduce the adversarial incentives built into the current project approval process
- Educating public leaders
- Educating the public on alternatives, values, and costs
- Training technical people in effective project presentation so they can communicate better with stakeholders
- Case studies of project approval (domestic and international examples)
- Preparation of systematic capital investment strategies
- Review of the transportation improvement plan (TIP) process for metropolitan planning organizations (MPOs): TIPs and MPOs are part of planning process established by ISTEA, now TEA-21.

4.5. Hazard Management

This breakout group began by discussing some common assumptions about hazard management. These include projections about the future, such as an increase in the frequency and magnitude of hazard management and an increase in vulnerability to hazards resulting from infrastructure projects. They also include the cognitive aspects of hazard management, such as people's difficulties assessing risk and their fear of catastrophic events. For example, there is more political will to invest in reducing uncertain but catastrophic events than in the mitigation of risks that are more likely to affect the population. The group also noted that society's responses to hazard management are often inadequate. Communities tend to respond to hazard management after an incident. For service providers, it is often cheaper or more practical to fix infrastructure problems when things break or fall apart; but to society, there may be much higher costs associated with such maintenance strategies that need to be considered.

The success of insurance programs in providing the right incentives to service providers is limited. After the Northridge earthquake, for instance, many insurance companies stopped doing business in California. The group discussed how the costs associated with these events could be reduced. Another example of an absence of incentives for adequate hazard management is Royce Hall, on the UCLA campus. Since no seismic work was done when it was rehabilitated, the building was leveled in the 1994 earthquake. The Chancellor said the state didn’t allocate the funds to do the seismic retrofit, and donors didn’t want their money being used to pay for it either.

Another problem related to hazard management is the difference between the content and the enforcement of regulatory codes to prevent hazardous incidents. According to the group, enforcement is often inadequate. For example, homeowners believe that these codes will protect them. However, it is an educational process, because oftentimes the public doesn't understand what the code actually provides for. It is also a matter of perspective. Another example concerns repairs made to homes for the elderly. The attitude that "they won't be around that long" sometimes leads to patchwork repair rather than improvements to a building. Such attitudes and perspectives can increase the risks of hazardous events associated with infrastructure.

According to the group, the most relevant issues are the potential impact of intelligent technologies (IT) and the impact of privatization. IT has an important role in extending the life of various infrastructure systems and may reduce maintenance expenses. IT can be used to monitor infrastructure performance and can allow managers to intervene before problems are likely to arise. As such, IT can be thought of as a hazard management tool. However, IT is also likely to result in tightly coupled systems, which will probably result in greater vulnerability and more frequent events, and thus produce high societal risks.

The risks associated with privatization stem from the fact that deregulation and reduced government participation may reduce coordination of infrastructure systems that are often linked. The prospect that infrastructure systems will become even more multi-jurisdictional, with responsibilities shared by public agencies and private service providers, poses important challenges to hazard management.

Members of the group suggested that ICIS could pursue several research topics in this area, including the study of the impact of IT and its associated risks, and the impact of privatization. They also agreed that curricula in the nation's education system, including both K-12 and post-secondary school systems should incorporate system risk and decision analysis.

4.6. Techno-diversity and its Relevance to Sustainability

This breakout group examined the extensive possibilities available to combine current technological options with people's infrastructure needs.

Goals

The group agreed that the main goal to discuss was the plurality of solutions to infrastructure service delivery. Members also felt that the processes and products that result from these solutions have a very important impact on sustainable development; thus, sustainability has to be built into civil infrastructure projects.

Scope: Alternative Issues

The scope of technology to provide sustainable solutions to the provision of infrastructure services is immense. It includes transportation (mobility), water supply, wastewater treatment, solid waste, power supply, transmission and distribution, and communications. All these aspects of civil infrastructure have an important bearing on natural resource use, particularly land use

patterns. Hence, the group felt that their ecological impact and their effect on biodiversity should be considered at the earliest stages of project design and planning.

The Issue of Mobility

Of the infrastructure services mentioned above, the group concentrated on mobility. It agreed that the most important goal for mobility is improving quality of life, including many aspects of accessibility. One is the ability and freedom to get to places in an affordable and safe manner. Young, old, poor, and infirm groups within the population need access to activities related to jobs, school, meeting friends and relatives, shopping, recreation, nature, and culture. Improving quality of life also implies gaining access to places quickly and at low cost, while minimizing the secondary effects of these activities: pollution, disturbing the landscape (aesthetic considerations), elimination of others' access to mobility, and excessive use of energy and resources.

Another impact that should be considered is infrastructure's potential for excluding or separating communities and specific groups. This can concentrate crime in particular areas, limit access to good schools, or prevent people from satisfying other values. The group also felt strongly about the quality of commuting and people's ability to formulate their own schedules; both factors significantly affect the quality of life. The group recommended further discussion about whether the solutions that incorporate quality of life factors into mobility will require multiple transportation modes.

Mobility Modes

It was agreed that current technology provides for a wide variety of choices of travel. These include individual vehicles such as the automobile, taxis, buses, mass transit (light rail, rapid transit, and heavy rail), boats, airplanes, high-speed rail, elevators, bicycles and other human powered vehicles, skateboards, in-line skates, mopeds, horses and animal powered vehicles, wheelchairs, and walking. Some of these choices, like cars, enhance accessibility (a value mentioned above), but have high social and environmental costs. Others, such as walking and bicycling, have low environmental costs but restrict access to some places and sometimes pose safety problems. The group suggested that the opportunity to walk be monitored for its contribution to sustainability in a given community. The opportunity to walk could be determined by such characteristics as the existence of sidewalks, safety, interest on the part of community members, the availability of destinations, and the ability to cross streets.

Conclusions

The group concluded by stating that technological options for infrastructure systems, especially for mobility, should pursue future infrastructure renewal and growth projects whose priorities include environmental sustainability and community strength. The aim is to ensure pluralist infrastructure systems of ever-increasing quality, inter-modal ease, aesthetic continuity, and choice for all types of communities in the United States.

5. Participants' Suggestions for ICIS

One of the goals of the conference was to obtain participants' views on which issues ICIS should concentrate. In a brainstorming session, three broad areas (performance measurement assessment; community awareness and participation; and education) and several topics within those areas were mentioned. Next, participants were asked to discuss their ideas in a "Samoan circle." The results of the brainstorming session and the discussions are summarized here. A final section lists those research topics that participants felt were most important.

5.1. Performance Measurement Assessment

Topics Considered

- Fund research on the politics and political processes of public works
- Forecast land value as a result of public works
- Include performance assessments for salmon as well as people
- Determine private economic gain
- Assess the public health benefits of infrastructure
- Assess ecological footprint
- Disaggregate benefits and costs
- Define "performance"
- Develop objective condition indices
- Measure interdependencies
- Assess resource extraction impacts
- Assess the value added of public works rather than the minimum cost of public works
- Assess total impacts on resources
- Document life cycle costs
- Evaluate standards at the local and national level
- Develop measures of inclusive planning involvement
- Include aesthetics
- Develop trade-off methods

Discussion

1.Integrated or Wholistic Thinking About Infrastructure Performance (Life Cycle Perspectives):

Bill Nye: All the needs for infrastructure have to be integrated. You can't separate out costs and benefits and aesthetics from the intended use of infrastructure. As former Texas governor Ann Richards says, it's not schools or highways; it's everything at once. That is what politicians are hired for. So I think benefit/cost analysis and aesthetics, all has to be done at once. Separating things out doesn't work. Why can't a good assessment do all of that?

Vivian Loftness: The implications of not maintaining something, e.g., the generation of wastes, tearing it down, should be included. Otherwise we are always doing first cost decision-making for each piece. Life cycle analysis is a problem – it is not being recorded. For instance, should

you maintain bridges, or replace them after 30 years? The necessary information is just not there. We have a throwaway mentality. Infrastructure is crumbling the fastest, and it is in the worst shape, because it is hidden.

Jennifer Wolch: What is life cycle? Just a system, or being whole with nature?

Bill Nye: Does someone really design bridges that only last 30 years?

Ted Lowi: Look at Broadway and Columbus Circle here in New York. Broadway makes a square or a circle as it transects other streets. Columbus Circle is obsolete. Shouldn't the capital product last as long as the bond? Capital financing is done in cycles of about 30 years. We need to re-evaluate this process.

Nancy Connery: The challenge is that people think aesthetics is more expensive. But actually, beauty can be cheaper. Aesthetics should be part of engineering, but it's been chewed off.

Vivian Loftness: Sustainable investment is more expensive. Wrought iron is more expensive than chain linked fence. Concrete is more expensive than glass.

Luis Suarez-Villa: We should think about longevity issues. This is related to the political process, the way financing happens at the local and regional level, and the appropriations process for repair.

Ted Lowi: This implies that we should endow monies for infrastructure up front to take into account life cycle considerations.

Richard Schuler: We want to think in terms of more fundamental attributes that people are looking for to satisfy through the use of infrastructure in establishing performance measures. A life cycle assessment is an evaluation mechanism that doesn't begin with the desires we are trying to satisfy.

Vivian Loftness: Life cycle assessment is central, not just a mechanism. ICIS should take it to the next step. ICIS should do more focused work on reliability and cost, but take it down to the next level. There is a universality across systems or locales, not based just on what they provide.

Richard Little: More focused work on the next level of measures is needed, and on the universality across systems. We need to look at the range of other things that a community wants from its infrastructure. We should look at performance with respect to what people want, as well as the benefits.

2.ICIS Products in the Area of Performance:

Richard Little: What product should ICIS produce?

Vivian Loftness: ICIS should produce a lot of tables of information.

Tom O'Rourke: ICIS should estimate life cycle costs.

Richard Little: We are ignoring the fact that there is a community of people who make their living on repairing stuff that wears out. There are interests here and no good data on it. ICIS could look at this, and produce information about it.

Vivian Loftness: There are indirect costs and life cycle impact costs, and these are two separate issues that ICIS could explore.

Roy Sparrow: There is also the issue of value-added impact versus costs and benefits.

Amy Helling: We need to get people enthusiastic about public works, to sweeten the deal. Bringing in artists is considered to be in direct opposition to cost/benefit analysis. Nancy says that it started that way, but bringing in art costs the same or less.

Ted Lowi: The New York City Art Commission is the most powerful entity concerning the aesthetics of public works in the city. This is an example of a formal public authority looking at aesthetics. Is there a way to establish such a formal authority?

Bill Nye: What is the product? A public document? We can look at books like those published by the Association for the Advancement of Science as examples. They have these nice books that have pages that look serious enough but are not permanent. We should think about books that are less than 50 pages and that describe the things that people should keep in mind when funding, in building successful infrastructure, etc.

Vivian Loftness: Some infrastructure gives more choice than others. There is little choice for a sewage treatment plant. For a car, there is a broad list of choices. Is it necessary to have choices? If you know you could do this and that, would it matter?

Bill Nye: In Seattle, a sewage treatment plant smelled. A bond issue was proposed for turning biosolids into fertilizers. Could ICIS ask voters how much they want it to smell, and if they want a bioproduct?

Roy Sparrow: We could have a catalog of infrastructure options.

Al Wallace: We need to be consistent in how we measure, and we should rank things at least categorically. We should also talk about efficiency, effectiveness, and equity.

Patrick Killackey: We should be looking at private industry for ways to measure performance and for examples. Companies run profit centers and are efficient.

Chris Anderson: About choices: I have a problem with the concept of a menu, because there are different choices and trade-offs at every level. I would not advocate that ICIS put out a document saying this is how you should vote on things.

Stuart Harris: Use your imagination in the design of products. The products shouldn't only be papers but also CD-ROMs, video, etc.

Rae Zimmerman: ICIS could create measures for infrastructure that people understand. People don't relate to parts per million and other technical measures. They relate to more fundamental things. We want to get to the broad things they react to and go back to agencies and ask them whether that makes sense to them and why they don't measure those things. We should also ask them, "Does this direction make sense?"

5.2. Community Awareness and Participation

Topics Considered

- Decide how to decide
- National standards for community participation
- Supply data and information to all stakeholders
- Define "stakeholder"
- Identify incentives to encourage people to become involved
- Impact on taxes of new infrastructure development
- Primer on infrastructure
- Transparency on who benefits
- Web-based information
- Determine how people want to be involved
- Recommend ways for community members to participate
- Examples of community codes
- How to simplify choices
- Ways to show people what options they have (e.g., Web, community meetings, interactions)
- How to deal with dichotomy: who pays/who benefits
- Improve the quality of those who guide community participation
- Examples from other places
- Visual/virtual reality as a tool

Discussion

Stuart Harris: How something benefits a community is not transparent. What is the distribution of responsibilities? Who is receiving the impacts and the benefits? Who pays and who benefits? There is always a group of people who benefit more. Infrastructure could help do things more equitably.

Rae Zimmerman: How do you get people to pay for things that benefit others?

Stuart Harris: There are common benefits.

Amy Helling: How do you get all of us to pay for what others use?

Ted Lowi: Some costs and benefits are deliberately hidden.

Jennifer Wolch: One way to do it is to define stakeholders, bring them together, and get them to shake up the way people think. If this is not the mindset nothing will change. Different people need to get involved.

Richard Little: Direct costs are also important. Why should Washington D.C. pay for flood projects in the Midwest? This is an issue. Externalities need to be quantified.

Stuart Harris: We need to think globally. Outer space is not local. Look at what is in your grocery stores. That stuff used free infrastructure to get to the market.

Amy Helling: Land value forecasts for new infrastructure are very important. What are the consequences? These forecasts could be depicted on a map on the Web along with ownership maps so people can see who owns it. This could be done with Geographic Information Systems.

Nancy Connery: We need to document what's been done to stretch the imagination to bring forth ideas. What tools can you bring to the process?

Chris Anderson: I'm not sure that Amy Helling's value-added models get at it. There is a need for a broader ability to understand the relationship between the different components of infrastructure. People have difficulty finding the time to participate in these discussions. You can have all the tools in the world, but you have to be able to get people to use them. How are we going to get people's attention?

Roy Sparrow: We can supply data and information. Usually there are competing data sets; there is an obligation to provide information. The disadvantaged cannot supply this. You don't participate equally if you don't have the information.

Tom O'Rourke: We can look at the measurable cost of projects and what it takes to get the community involved. For instance, consider the Boston Central Artery: the cost will be $12 billion, of which $6 billion has come from community trade-offs. At the end of the day, people have to say how much it's going to cost. This is a trend. Bringing in the community will bring expenses, and we need to understand this better. The public does not understand what the real costs are. We need to lay them out in the form of case histories.

William Petak: There are lots of little projects. We need a means to get small communities involved in small projects to understand costs, social and otherwise. The product could be software.

Al Wallace: Gaming and simulation is the way we are learning now, and this is extremely important for education.

Roy Sparrow: We can also be positive. Infrastructure can be an opportunity, and this alters the psychology of communities. The positive qualities of infrastructure should be paid attention to as well.

Tom O'Rourke: A problem is you don't know what the factual baseline is. The scope changes, and that changes costs. Then the media comes in and makes things worse by highlighting cost overruns and things like that. In the case of the Boston Central Artery, the *Boston Globe* only picks up on cost overruns and stirs things up. This does not help.

Bill Nye: This means that you need marketing. Get together with the people at the *Globe* if you need to.

Allen Zerkin: The problem is one of sequencing. If the public is not involved early enough, then your cost overruns will be big. There is no need to reinvent the wheel; there is a profession that gets people to participate. The NIMBY case is the easy one, because people are involved. Not bribery - there are ways of talking about it. The hard case is getting people to talk about trade-offs when they are not directly/particularly involved – i.e., more generalized issues.

Richard Schuler: The sequencing is crucial: We need to confront the indirect consequences of our behavior.

Vivian Loftness: We should be thinking about the cost per number of users rather than just first costs, i.e., $168 million in urban versus suburban areas in terms of users and additional functions. If discussions are only about first costs, we are lost.

Amy Helling: Compare NIMBY to cases where there are no incentives to participate. Infrastructure and land use are combined.

5.3. Education

Topics Considered

- Education for educators
- Right learning objectives
- Types of learning objectives
- Individual responsibility re: education, infrastructure
- Advanced technologies
- Conflict resolution
- Case studies of non-sustainable infrastructure
- Learning from non-professional communities
- Effects of infrastructure at different stages
- Define "right"
- Tactile infrastructure
- How does education relate to technology?
- Cultural diversity
- Audience versus stakeholder
- How do you teach flexible mental frames?
- Interdisciplinary team processes

Discussion

Bill Nye: He indicated that the group is commonly using the term, “we know.” The phrase “we know” is dangerous. ICIS people should be learners.

Vivian Loftness: There is a hurdle to overcome in higher education, and that is teaching students to make individual decisions. Most schools discourage students from sharing information; they ask students to compete for the right answers. Another example is how the power line manager works alone, and he doesn’t know that the protector of trees needs to be a part of the answer to problems that arise.

Rae Zimmerman: I have this conflict over term papers in my class, on whether to allow joint papers or only individual papers.

Bill Nye: One way to deal with this is to assign group projects and let them grade each other.

Vivian Loftness: Without a multi-disciplinary approach to education, we can’t get to sustainability.

Ted Lowi: Is there a way to teach by looking at cases of failure?

Roy Sparrow: We need to educate the educators. The demand on educators is tremendous.

Jennifer Wolch: Educators should go to very different contexts to see what's happened and what solutions have been found. This would shake up their thinking.

Bill Nye: ICIS should have a representative at the National Science Teachers Association. You could have a booth and provide outreach materials for teachers that are concise and interesting. ICIS could develop a stamp of approval and get certain manufacturers to strive for this approval.

Vivian Loftness: A good task for ICIS would be to look for good products and outreach materials that could be packaged. You don't have to re-invent what is already there.

Amy Helling: ICIS could provide a means of linking practitioners with teachers. For example, I don't have enough time to seek out places to visit. There could be bulletin boards to connect teachers who want to do field trips.

Al Wallace: ICIS could develop cases that focus on systems, i.e., holistic cases, and put them out as videos. They could involve role playing on how to educate people. You only need to develop one or two that are very rich and comprehensive. For example, one could be on the Port Authority of New York and New Jersey.

Roy Sparrow: Games intrigue me. They get people inside and help them see the consequences of their actions.

Bill Nye: ICIS could be a consultant to people who write games: developing games is actually very difficult.

5.4. Research Priorities

Finally, participants were asked to name some major research topics and then vote for the three most important ones. In the following list, the numbers in parentheses refer to the number of votes received by each topic.

- Intangible infrastructure (knowledge, etc.): what it is and what it means (6)
- Sustainability implication of edge cities (1)
- Cradle-to-cradle approach (1)
- Obsolescence of infrastructure systems (2)
- Possible new professions (3)
- Financing infrastructure in the Third World: this topic is also related to global implications of local decisions (7)
- Ethics of infrastructure development. It was also mentioned that this topic is related to global implications of local decisions (6)
- Cultural impacts of infrastructure (4)
- Alternatives to infrastructure growth and tools for redistribution of growth (10)
- Case studies of highly innovative, global, standard practices (12)
- Global implications of local decisions (0)
- Gains/benefits of plural solutions (5)
- Looking at infrastructure decisions unique to national disasters (2)
- Social implications of growth (0)
- Putting literature in coherent, accessible form; this could be an approach to other topics (3)

On the basis of the number of votes received, therefore, the following three research topics were considered to be the most important ones for ICIS to pursue:

1. Case studies of highly innovative, global, standard practices
2. Alternatives to infrastructure growth and tools for redistribution of growth
3. Financing infrastructure in the Third World.

6. Synopsis of Significance and Directions for ICIS

Introduction

Sustainability refers to a balance of activities that live within the boundaries of the Earth's capacity, and do not utilize resources faster than they can be regenerated. It also refers to the need to maintain existing resources for future generations.

ICIS has identified sustainability as a framework for thinking about infrastructure and its renewal, and as such, it is an overarching framework to guide its program areas. ICIS derived a number of ideas and recommended courses of action from the conference, both directly and indirectly, and some of these are described below. In general, the conference:

- Reinforced and advanced the ICIS mission to connect infrastructure, its users, and affected communities,

- Suggested new directions and new efforts ICIS should undertake,

- Identified new research agendas for others as well as ICIS, and

- Improved the understanding of the overall societal need for infrastructure and its relationship to and compatibility with the natural and human environments.

Coordinated infrastructure renewal in light of sustainability sheds light on:

- the size of the system to be considered; the factors to be considered in broadening the infrastructure domain

- how decision-making should be structured for a broader picture

- the boundaries and components of a system; change the timing and nature of what you do.

Infrastructure in the memories of the participants was an exciting part of their childhoods. This excitement and positive thinking needs to be recaptured.

An overarching recommendation was that ICIS should develop the means to integrate all of the needs for infrastructure simultaneously, since they are all interconnected. A second recommendation was for ICIS to develop an information base, including, for example, life cycle costs of infrastructure. A third set of recommendations focused on ICIS products, and those suggested broke away from the typical paper and report mode to include CD-ROMs, videos, games, software, etc.

Programmatic Implications

1.Education

The Connery paper set forth a number of generic ideas that represent what is central to a system of education focused on infrastructure that is integrated with users and communities:

- We need a new mental model of civil infrastructure systems that resonates with the same dynamism and unity that are true of living systems.

- Building a strong symbolic "bridge to the community" is the most important priority for infrastructure renewal, and this should be designed along environmental values.

- Infrastructure professionals need to broaden their palette of creative approaches to problem solving by inviting a wider range of perspectives to the design table.

- We need to infuse civil engineering education with a clear understanding of the social, economic, environmental, and aesthetic issues that affect the complex environment of contemporary life.

Some specific recommendations for the ICIS education program included:

Sustainability highlights the loss of communities and the public connection to infrastructure, the lack of knowledge about infrastructure, and the lack of understanding of the relationship between individuals and infrastructure systems. These factors must be addressed early in the educational system, underscoring a focus on K-12 programs.

ICIS should educate the educators, having representatives at major education conferences and providing products and outreach materials for curriculum development. ICIS should also develop mechanisms to link practitioners and teachers, using mechanisms such as bulletin boards and videos.

2.Community Awareness

ICIS can communicate the concept of sustainable infrastructure to the public.

Recommendations for ICIS included analyzing areas where there is lack of information and identifying ways to help citizens make better decisions and increase their participation. ICIS should try to understand the knowledge base for a project or system and determine who is involved and the role of the law in the process. In short, ICIS needs to identify successful efforts and distill them into processes that can be applied elsewhere or into lessons to be learned. ICIS should be a service organization for the public, not telling the public what it wants.

The group recommended that ICIS study models of conflict resolution and stakeholder participation in other countries and contexts and examining their feasibility in this country.

Conflict resolution and stakeholder participation are already components of the Community Awareness and Participation program, and international perspectives could be added. Issues ICIS should address in this area are how to:

- Ensure the early involvement of stakeholders in the process
- Promote an understanding of impacts of infrastructure projects (2^{nd} and 3^{rd} order impacts)
- Incorporate constructive incentives in the process: Are there any? If so, what are the trade-offs between efficiency and equity?
- Reduce the adversarial incentives built into the current project approval process
- Educate public leaders
- Educate the public on alternatives, values, and costs
- Train technical people in effective project presentation so they can communicate better with stakeholders
- Develop case studies of project approvals (domestic and international examples)
- Prepare systematic capital investment strategies
- Review the transportation improvement plan (TIP) process for metropolitan planning organizations (MPOs) (TIPs and MPOs are a formal part of planning process established by federal transportation legislation, ISTEA, now TEA-21).

3.Performance Measurement

ICIS can develop methodologies to break down projects and systems into measurable components of sustainability, such as energy use, materials, and others. By developing a set of measureable performance standards based on the concept of sustainability, ICIS could help inform decision-makers and enable them to move infrastructure in a more sustainable direction.

4.Research Agendas

Several research areas that ICIS could set forth for the infrastructure community at large were explored. The three most popular topics identified were: case studies of highly innovative, global, standard practices; alternatives to infrastructure growth and tools for the redistribution of growth; and financing infrastructure in the Third World.