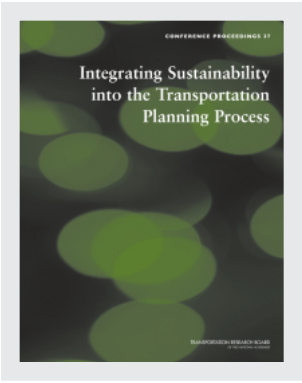

Integrating Sustainability into the Transportation Planning Process (2005)

DETAILS

59 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-09418-4 | DOI 10.17226/13878

CONTRIBUTORS

SUGGESTED CITATION

National Academies of Sciences, Engineering, and Medicine 2005. *Integrating Sustainability into the Transportation Planning Process*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13878.

CONFERENCE PROCEEDINGS 37

Integrating Sustainability into the Transportation Planning Process

Committee for the Conference on Introducing Sustainability into Surface Transportation Planning

Baltimore, Maryland
July 11–13, 2004

Sponsored by
Transportation Research Board
Federal Highway Administration
U.S. Environmental Protection Agency

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Washington, D.C.
2005
www.TRB.org

Transportation Research Board Conference Proceedings 37
ISSN 1073-1652
ISBN 0-309-09418-6

Subscriber Category
IA planning and administration
IB energy and environment

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Printed in the United States of America.

The conference was sponsored by the Transportation Research Board, the Federal Highway Administration of the U.S. Department of Transportation, and the U.S. Environmental Protection Agency.

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Preface

In July 2004 approximately 70 people assembled in Baltimore, Maryland, to participate in the Conference on Integrating Sustainability into the Transportation Planning Process. The conference, organized and conducted by the Transportation Research Board (TRB), brought together individuals from across the transportation, energy, environmental, land use, planning, and public policy communities—at national, state, and local levels and from the public and the private sectors. The public sector was represented by officials from the U.S. Department of Transportation, the Federal Highway Administration, the Federal Transit Administration, and the U.S. Environmental Protection Agency as well as from state and regional organizations. Private-sector participants included members of academia, individuals from trade associations, automotive industry professionals, and consultants.

Sponsored by TRB, the Federal Highway Administration, and the U.S. Environmental Protection Agency, the conference was conducted under the auspices of TRB's parent organizaton, the National Research Council (NRC). A specially appointed NRC committee developed the conference as a forum to exchange perspectives on the challenges and potential solutions to the challenges of integrating sustainability concerns into the transportation planning process. Drawing on the resource papers, presentations, and conference discussions, the conference committee evaluated the current state of the practice, considered strategies for integrating sustainability concepts into transportation planning, and identified areas for further research.

Conference Program

The conference program was designed to maximize the exchange of information and perspectives among participants. To gain a better understanding of all of the viewpoints presented, the reader is encouraged to read the report in its entirety.

The program began with a general session (General Session 1) that included a welcome from the Federal Highway Administration, a sponsor of the conference; the presentation of the conference charge by the conference committee chair, David Greene; a keynote address by Thomas Deen; and presentation of the first of two resource papers developed for the conference—"Sustainable Transport: Definitions and Responses" by William Black.

In General Session 2, participants heard from experts on six indicators of sustainability: health, climate change, energy, equity, land/community, and habitats/ecosystems. In General Session 3, the second resource paper was presented—"What Are the Challenges to Creating Sustainable Transportation? How Can Transportation Systems Become More Sustainable?" by Martin Wachs.

The conference program then separated the participants into four concurrent panel sessions organized into substantive tracks. Each concurrent session included a facilitator who served to energize and spur discussion and a rapporteur who recapped the discussion highlights. Concurrent Sessions I focused on the challenges of sustainable transportation, and Concurrent Sessions II requested the participants to discuss potential solu-

tions to the challenges. In General Sessions 4 and 6 the rapporteurs provided summaries of the concurrent session discussions to stimulate the exchange of views among conference participants.

In General Session 5 industry experts participated on a panel in which they presented approaches to the challenges of sustainable transportation. In addition to the general and concurrent sessions described above, the conference included two luncheon speakers and a poster session. By the close of the conference, participants not only had collected a significant amount of information but also had exchanged perspectives.

Acknowledgments

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by NRC's Report Review Committee. The purposes of this independent review are to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

The conference committee thanks the following individuals for their review of this report: David J. Forkenbrock, University of Iowa, Iowa City; Francis B. Francois, Consultant, Washington, D.C.; Charles E. Howard, Jr., Puget Sound Regional Council, Seattle, Washington; Ashby Johnson, Houston–Galveston Area Council, Houston, Texas; Lee Schipper, World Resources Institute, Washington, D.C.; and Sarah J. Siwek, Sarah J. Siwek and Associates, Inc., Los Angeles, California.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by NRC, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Committee Findings and Recommendations

The idea of a sustainable society in which the needs of the present are met without compromising the ability of future generations to meet their own needs is compelling. Despite its many dimensions and uncertainties, sustainability is generally agreed to be important and worth pursuing. At the same time, current trends in transportation contribute to unsustainable conditions, including climate change, energy insecurity, congestion, noise pollution, and ecological impacts. Widespread uncertainty exists about how to address the goal of a sustainable transportation system. What is clear is that attaining a sustainable transportation system will require action by the public sector, private companies, and individual citizens. Given the complexity of the issue and the variety of players, it also will require a major cultural change to raise and organize societal awareness.

The effort to form a culture in which sustainability concepts are legitimized and integrated into transportation planning is just beginning and will likely involve a long learning process. The Transportation Research Board (TRB) Conference on Integrating Sustainability into the Transportation Planning Process examined whether and how sustainability objectives can be introduced into the planning process for surface transportation facilities and operations.

After the final conference session, the TRB Committee for the Conference on Introducing Sustainability into Surface Transportation Planning convened to develop its findings, which were based largely on the presentations and discussions at the conference. A summary of the committee's findings and recommendations follows. They are organized into four sections:

- Issues of sustainability,
- Vision of a sustainable transportation system,
- State of the practice, and
- Strategies for integrating sustainability concepts into transportation planning.

Issues of Sustainability

The concept of sustainability has a powerful grip on people. Few could disagree that attainment of a sustainable transportation system is desirable; however, many challenges lie along the path to achieving such a system. The nation's transportation system has enhanced quality of life through increased access to health care, education, employment, recreation, and a wide range of consumer goods. These benefits have not been achieved without costs. The negative impacts of the transportation system include congestion; fatalities and injuries; noise, air, and water pollution; greenhouse gas emissions; diminishing energy resources; and biological and ecosystem damage. The challenge of a sustainable transportation system lies in minimizing these costs while offering strong transportation benefits.

There have been some successes in responding to these challenges. Air quality regulations, for instance,

have resulted in substantial air quality improvements. Air pollution has not been eliminated, but air quality is better in most areas. This success and others provide encouragement that sustainable transportation challenges can be met. However, consistent effort is necessary, even in areas where progress has been made. Air quality has improved, but increasing travel volumes require continuing reductions in air pollution.

Numerous unsustainable impacts of transportation demonstrate the challenges faced in transitioning to a sustainable transportation system. A discussion of these impacts is provided below.

Nonrenewable Fuel Depletion and Energy Insecurity

The current transportation system depends on nonrenewable fuels. The rate of consumption of nonrenewable fuels is projected to grow as travel domestically and elsewhere increases. The challenge is in finding ways to reduce the rate of consumption of nonrenewable energy sources—including more carbon-intense unconventional sources of petroleum—through the development of renewable energy sources, improved energy efficiency of vehicles, and increased use of public and nonmotorized transportation. There are economic, environmental, and societal trade-offs associated with each of these alternatives.

Greenhouse Gas Emissions

The burning of fossil fuels to power transportation vehicles releases greenhouse gases into the atmosphere, which contributes to increasing global average temperature and other climate changes. Greenhouse gases are emitted throughout the fuel cycle, from well to tailpipe. The use of petroleum-based fossil fuels for transportation is responsible, directly or indirectly, for more than one-fourth of U.S. emissions of carbon dioxide, the principal greenhouse gas produced by transportation. Improved fuel efficiency and increased use of alternative fuels are proven options available to reduce greenhouse gas emissions over the entire fuel cycle.

Global Climate Change

An enhanced greenhouse effect will have significant impacts on sea level, climate, and agriculture. Impacts of the rise in sea level alone may include the flooding of tunnels, coastal highways, runways, and railways. Other impacts may include grounding of airplanes due to high temperatures, buckling of highways and railroad tracks due to heat, the submersion of dock facilities, and a shift in agriculture to areas that are now cooler. Such results demonstrate that reducing greenhouse gas emissions must be a top priority. The extent of mitigation will mainly determine the rate of climate change experienced by future generations. Because of the inertia of the climate system, adaptation will be necessary regardless of efforts to reduce greenhouse gas emissions from this time forward. It is probably too late to prevent or completely reverse climate change.

Local Air Quality

Motorized vehicles contribute significantly to local air pollution. Poor air quality has various negative health impacts, particularly on the respiratory system. Air quality, however, is one area where large gains have been made. Growth in transportation activity threatens to limit the effectiveness of existing strategies to reduce emissions. As a result, despite the progress that has been made, new methods, technologies, and policies to improve air quality are required.

Fatalities and Injuries

Unacceptable levels of fatalities and injuries occur on the nation's highways. A goal of zero fatalities and serious injuries is appropriate. Sustainability argues for a continuous decline in fatalities and injuries resulting in a safer transportation system.

Congestion

Congestion would be a sustainability issue even if an energy source were developed that had zero harmful emissions and was renewable. Congestion worsens motorized mobility. The rise in congestion is attributable not only to increased personal mobility and freight movement but also to a lack of adequate and reliable transportation funding. Congestion negatively affects the economic and social health of the nation and, if not addressed, will leave future generations without a reasonable level of mobility. Some observers argue that congestion can have positive implications for sustainability because congested highways cause some people to choose alternative modes of transportation.

Noise Pollution

The transportation system is a significant source of noise. Transportation noise originates from all motorized modes of transport. Examples of transportation-

related sources of noise include engines, vehicle contact with pavement and other surfaces, horns, construction, brakes, and airplane takeoff and landing, to name a few. Loud noise and continuous noise are harmful to human health. The impacts include behavioral disorders, heart disease, and hearing loss. Noise also disturbs wildlife. Studies of the breeding and habitat of birds have found that higher volumes of traffic affect the nesting patterns of birds. Noise harms human health and wildlife and can damage the quality of life.

Low Mobility

A reasonable level of mobility is an essential characteristic of a sustainable transportation system. Mobility is necessary for the nation's economy and for social and cultural interaction. Transportation must be available to all members of the community, including vulnerable groups such as persons with low income, children, the elderly, and the disabled.

Ecosystem Damage

Transportation activities can harm biological resources. The effects can range from the death of individual animals to the loss of critical habitat. Some impacts are localized, such as animals killed along highways, disruption of migration patterns, runoff that pollutes rivers and streams, oil tanker spills, and plants affected by emissions. Other impacts are more profound, such as fragmentation and loss of species and long-term damage to ecosystems. Improvements have been made with regard to the effects of transportation on ecosystems. For example, mitigation requirements for highways and other paved surfaces at airports, seaports, and maintenance garages have greatly reduced runoff impacts. The Endangered Species Act has provided significant protections. As population and travel volume increase, a continuous effort must be made to maintain and improve on areas of success.

Lack of Equity

Intergenerational and social equity are the overarching aims of a sustainable transportation system. In reducing the unsustainable impacts of transportation, as discussed elsewhere in this section, progress toward an equitable transportation system would be made.

The challenges to achieving a sustainable transportation system identified above provide a baseline for an action agenda that can lead to a sustainable transportation system. Properly planned transportation systems can play a central role in promoting sustainability.

Vision of a Sustainable Transportation System

What would a sustainable transportation system look like? Outlining the basic components of such a system is an important step in progressing toward sustainability, even if the resulting vision is not entirely clear.

At the most basic level, a sustainable transportation system is one that meets the transportation and other needs of the present without compromising the ability of future generations to meet their needs. In considering the needs of future generations, however, the benefits of the present transportation system should not be excessively inhibited or used as the justification for precluding future choices. Transportation planners and providers must continuously struggle with the trade-offs between the economic and societal benefits of transportation and the associated unsustainable environmental, safety, health, ecosystem, and equity impacts.

A sustainable transportation system requires a culture that not only sees sustainability as desirable but also accepts the inclusion of sustainability concepts in the transportation planning process and supports the tough decisions necessary to make sustainability a priority. The public and policy makers in this culture will understand and consider potential solutions, such as integrated land use and transportation and innovative public transportation (for example, bus rapid transit and car sharing).

This cultural acceptance will be supported by the provision of adequate and reliable transportation funding consistent with fiscal constraints. Legislators and policy makers will recognize that a sustainable funding source is needed to meet current mobility needs while addressing the unsustainable effects of transportation. In addition, transportation providers must be able to ensure that investments in transportation facilities have adequate operations and maintenance funding.

A sustainable transportation system will have accountability in the planning process. Performance measurement and feedback loops will enable planners to learn from past experiences and understand fully the ramifications of decisions on the components of sustainability. Continuous improvement enabled through flexibility and innovation will be a key element of sustainable transportation as travel patterns, vehicle and fuel technologies, land use patterns, population densities, and individual travel choices change.

State of the Practice

On the basis of the ideas and issues addressed at the conference (and summarized elsewhere in these proceedings), the committee developed a set of observa-

tions about the state of the practice with regard to sustainability concepts and transportation. These are organized into two categories: (*a*) political, legislative, and regulatory findings and (*b*) transportation planning process findings.

Political, Legislative, and Regulatory Findings

Lack of a National Sustainable Transportation Policy

There is no effective national policy with regard to the sustainability of transportation. A national policy on the need to integrate sustainability concepts into transportation planning could facilitate the development of legislation, regulation, guidance, and other tools. The new tools would support changes in current practices that are unacceptable because they fail to emphasize or ignore notions of sustainability.

Innovative Solutions Often Discouraged by Current Standards and Regulations

Innovative transportation solutions that could address sustainability issues are often discouraged by inflexible and outdated regulations, rules, codes, and standards. Examples of such innovative solutions are improved fuel economy standards, full-cost pricing, certain transportation infrastructure and vehicle technologies, and alternative energy sources and fuels. Flexibility must be provided to enable minimization of adverse sustainability impacts.

Transportation Planning Process Findings

Transportation Planning Horizons Not Long Enough

Federal regulations relating to transportation and air quality require states and metropolitan planning organizations to complete long-range transportation plans and programs for a 20-year forecast period. For transportation planning processes to integrate sustainability objectives, the forecast period must be at least 40 years. Some planning organizations have begun to extend their planning horizons, but the practice remains limited.

Assessment of Transportation Impacts Not Sufficiently Broad

The effects of transportation on climate change are not usually considered in the planning process. In certain areas, such as road ecology, some effects are considered, such as the presence of endangered species in the planned corridor. Other effects, however, such as the impacts of noise on the breeding and migration patterns of birds, are not commonly considered. A more coherent and integrated road ecology approach is needed. Transportation planning, particularly in urban areas, is based on already adopted land use plans and objectives. Integrated transportation and land use decision making has not been realized. Land use planning and zoning remain the prerogative of local governments that strive to optimize their own objectives, which often directly relate to maximizing local tax revenue. Planning processes also do not give appropriate importance to the role of freight and its impact on sustainability.

Existing Institutional Structure Permits Integrating Sustainability into Planning

Sustainability objectives can be introduced into the transportation planning process within the current institutional structure. State departments of transportation and metropolitan planning organizations, for example, are capable of incorporating sustainability into their planning processes. Indeed, sustainability practices and tools do exist and are utilized by some states and planning organizations, but not widely. The barriers to implementing sustainable transportation planning within current organizations are more cultural than institutional.

Strategies for Integrating Sustainability Concepts into Transportation Planning

In line with its findings, the committee developed a set of recommendations focused on updating and improving the planning process, providing public and professional education, and identifying areas for further research. Given the complexity and scale of the sustainability challenge, the committee first pointed to three areas where broadly based action is needed to achieve greater coherence and consensus on sustainability, both nationally and internationally:

- **Adopting a national statement of values and definitions on sustainability, including a transportation component with specific national objectives and performance measures that can support review and revision of the objectives.** Possible objectives include the reduction of greenhouse gas emissions from transportation sources via energy efficiency, reduction in the use of nonrenewable transportation fuels, and support of nontechnological solutions such as incentives for use of nonmotorized transport and public transportation.

- **Building consensus on a sustainability policy across all levels of government—federal, state, regional, and local.** To lead effectively in communication and consensus-building activities across relevant agencies at all levels of government, the U.S. Department of Transportation will need to determine how to bring about this collaboration and how best to support the efforts of local governments to tackle transportation sustainability.
- **Cooperating with other nations to address the global dimensions of sustainable transportation.** With impacts that are global as well as local and regional, this inherently international issue requires that the United States work cooperatively with other nations to address sustainable transportation effectively.

The committee made the following recommendations for integrating sustainability concepts into transportation planning.

Planning Process Recommendations

Adopt Sustainability as a Primary Objective of Transportation Planning

At all levels of government—federal, regional, state, and local—use of sustainability criteria should be a central feature of transportation planning. A goal of transportation planning should be to address transportation's unsustainable impacts, including depletion of nonrenewable fuels, climate change, air pollution, fatalities and injuries, congestion, noise pollution, low mobility, biological damage, and lack of equity. These criteria should be built into planning guidelines and processes. In addition, transportation planning should be proactive and promote sustainability through practices such as integrated land use and transportation planning and cross-modal planning. Transportation planning also should conduct forward-looking analyses of demographics, market preferences, and job location trends to be responsive to the emerging needs of future generations.

Use Existing Institutional Structure but Address Cultural Issues

The existing institutional structure of transportation planning—state departments of transportation, metropolitan planning organizations, and local planning agencies—is capable of integrating sustainability objectives into the transportation planning process. Planning agencies nevertheless face cultural challenges that must be overcome to address unsustainable transportation impacts. Cultural issues must be accommodated to enable the incorporation of sustainability-friendly solutions such as integrated land use and transportation planning, cross-modal planning, and full-cost pricing. These solutions require transportation planners to reach beyond their traditional areas of expertise and work collaboratively with other agencies. Moreover, to enable accountability for transportation investment decisions, transportation planning institutions should be given budgetary and management authority.

Adopt Use of Inclusive Long-Term Visioning in Planning

Adopting longer horizons and visioning techniques in the development of transportation plans will enhance the ability of planning processes to integrate sustainability objectives. Standard 20-year planning horizons need to be extended to at least 40 years to incorporate sustainability concepts. In addition, public involvement should be expanded to enable plans that reflect a community's vision, have support from a broad constituency, and are therefore more likely to be implemented successfully. Underrepresented groups such as children, the elderly, and those with low income should be included in public involvement, along with industry, educators, and public health officials. In conjunction with visioning and longer planning horizons, backcasting should be encouraged. Backcasting involves working backwards from a particular desired future, or set of goals, to the present. A handful of planning institutions have begun implementing these practices, and their experiences can be valuable to other agencies.

Evaluate the Broad Range of Effects of Transportation Investments in the Planning Process

Transportation investments have a wide range of effects on the economy, the environment, and our culture. A broad transportation planning perspective should be implemented to enable planners to address more fully unsustainable effects such as congestion, lack of equity, climate change, air pollution, ecological degradation, and resource depletion. In tackling these effects, planning agencies should consider applying "triple bottom line" analysis to transportation planning. Triple bottom line analysis gives environmental quality and social justice equal weight with financial considerations. When transportation's full range of effects is considered in the planning process, innovative solutions can be developed that enable reasonable growth while addressing sustainability.

Education Recommendation: Educate Stakeholders in Issues of Sustainability

To build consensus and institutional capacity, education in the dimensions of sustainability including sustainable transportation is needed. Educational methods such as professional development and training; public outreach; institution building; information dissemination; and adaptation of elementary, secondary, and tertiary curricula should be applied to appropriate stakeholder groups. For example, planning professionals should receive uniform and legitimized training and education to augment planners' capabilities to include sustainability issues. Planning professionals need to be provided with the information, resources, and skills that can enable them to deal with the complex interrelated issues associated with sustainability. As another example, curricula on sustainability should be used in elementary, secondary, and tertiary schools to instill the values of sustainability in younger generations. The general public should be educated in sustainability and the importance of individual decisions and behavior through outreach and other forms of information dissemination.

Recommended Areas for Further Research

Methods and Models for Longer Time Horizon and Broader Reach Planning

Tools that enable the integration of sustainable transportation practices into the planning process should be developed. Tools are particularly needed in the areas of sustainable urban development, finance, freight, greenhouse gas emissions, road ecology, and public decision making. Research also is needed on the extent to which methodologies such as longer horizon planning, visioning, and backcasting will result in more sustainable transportation.

Individual Transportation Behavior

Research current behavior patterns and the circumstances under which current behavior might change. Research attitudes toward sustainability and environmental issues. These data will enable improved planning for the next generation of travelers, shippers, and carriers.

Alternative Energy Sources and Technological Advancements

Research innovative solutions to unsustainable effects of transportation including, but not limited to, the following:

- New vehicle and fuel technologies such as small specialized vehicles, plug-in hybrid vehicles, electric guideways, and fuel cell vehicles;
- Alternative vehicle concepts such as car sharing and smart paratransit;
- New low-carbon fuels such as biofuels, electricity, and hydrogen;
- More energy-efficient combustion engine vehicles;
- Sustainable means of freight movement; and
- Pricing and full costing of fuel and roadways.

Case Studies and Pilot Projects

Through pilot projects and case studies, research innovative processes, tools, and methods that demonstrate the integration of sustainability concepts into transportation planning. Case examples and pilot projects should be conducted with metropolitan planning organizations and state agencies to demonstrate innovations such as visioning; longer planning horizons; backcasting; ecological mitigation; land use and transportation integration; introduction of new modes, vehicles, and fuels; and cross-modal planning. Air quality attainment methodology can be and, in a few instances, has been easily adapted to accommodate greenhouse gas estimates. U.S. Environmental Protection Agency–funded efforts with state energy agencies have demonstrated the merits of pilot approaches. Metropolitan planning organizations and state departments of transportation are fully capable of undertaking meaningful efforts if federal funding could provide the necessary resources.

Conclusion

Achieving a sustainable transportation system—one in which (*a*) current social and economic transportation needs are met in an environmentally conscious manner and (*b*) the ability of future generations to meet their own needs is not compromised—is not a simple task. Certainly, the path to such a transportation system will be difficult. Transportation system planners and providers will need to work with and respond to market conditions, demographic changes, and political challenges; it will not be possible to envision achieving sustainability otherwise.

Despite the enormity of the challenges, transportation planning can play a significant role in a mix of public and private actions toward the goal of sustainability. Annually, tens of billions of dollars are invested in transportation facilities and services by governmental units in the United States. These investments leverage a far greater level of private transportation investment to sustain the economy. Transportation planning products generate, prioritize, guide, and authorize these strategic

public investments. Thus, whether decisions made within the planning process reflect or ignore sustainability concepts has a significant bearing on the likelihood of achieving a sustainable system.

In brief, two achievable adjustments will greatly help integrate sustainability concepts into transportation planning practices: (*a*) taking a *broader* view with full concern for transportation's impacts on public health, equity, and the environment; and (*b*) taking a *longer-term* view with full concern for future generations. While some emerging practices embrace these two adjustments, most current practices are still rooted in more limited, traditional technical methods, evaluation schemes, and time horizons. A national consensus concerning sustainability, facilitated by dialogue and technical assistance supported by the U. S. Department of Transportation, will be needed to ensure that the entire transportation planning community makes the necessary adjustments to integrate sustainability into planning practice.

General and Concurrent Sessions

Welcoming Remarks and Charge to the Conference

Jim Shrouds, *Federal Highway Administration*
David L. Greene, *Oak Ridge National Laboratory*

The Conference on Integrating Sustainability into the Transportation Planning Process began with a general session that included welcoming remarks from the conference sponsor and the conference committee chair.

Jim Shrouds, Director of the Office of Natural and Human Environment, Federal Highway Administration (FHWA), offered welcoming remarks on behalf of the conference sponsor. He compared the challenges of sustainable transportation to those of "the perfect storm." The three storm systems that unite to create these challenges are growth in population and employment, growth in travel and congestion, and growth in concern for the environment.

FHWA sees sustainable mobility as a systemwide issue and is undertaking various efforts in this area. In particular, cost-effective and sustainable mitigation research and development, ecosystem initiatives, and FHWA's Center for Global Climate Change, which researches ways to reduce greenhouse gas emissions and respond to the impacts on transportation infrastructure from climate changes such as a rise in sea level, were noted.

Three of the challenges that FHWA faces are (*a*) providing better linkages between transportation planning and environmental requirements in project development, (*b*) engaging stakeholders early and continuously in the transportation planning process, and (*c*) improving integration of transportation and land use planning at the local level. By facilitating discussion and expanding the horizons of participants, the conference is helping to meet those challenges.

David L. Greene, conference chair, welcomed participants to the conference and provided an overview of its structure and objectives. He charged participants to take ownership of the conference and, through their participation, to contribute to the overall success of the sessions and of the conference. The role of the conference committee members is to advise the U.S. government on how to incorporate sustainability into transportation planning on the basis of the results of this conference. Dr. Greene requested that the participants provide information and advice to committee members to assist them in meeting this charge.

Examples of working definitions of sustainability were provided, including the definitions supported by the United Nations World Commission on Environment and Development (the Brundtland Commission) and the definition provided in a joint statement of 63 of the world's scientific academies. Society cannot be sustainable if its parts are not sustainable, and transportation not only must be sustainable but also must contribute to the sustainability of society.

Dr. Greene noted that the conference has brought together an outstanding group of participants and excellent speakers for a program focused on obtaining participant input for the conference sponsors.

Keynote Address

Thomas B. Deen, *Consultant*

Thomas B. Deen began his keynote address by discussing previous efforts that have been undertaken on issues of sustainable transportation. Many of the participants in this conference were active 10 years ago, when work in this area was just beginning. Today, through this conference, participants are taking the concept of sustainability one step further and asking how to operationalize it and make it effective.

There are four broad human aspirations: peace, freedom, economic well-being, and a good physical environment. The last two of these are linked in that new industry (or economic well-being) often leads to environmental degradation. This is the crux of sustainable development—how to have economic growth without environmental decay. In the short term, jobs and growth tend to trump environmental concerns. Examples are the increase in the percentage of workers driving alone, the decline in carpooling, the drop in transit share, the increased length of the peak hour, the decline in urban density, and ever-increasing energy imports. On the basis of these facts, Mr. Deen cannot see how one can argue that sustainability has any traction in the real world; even the most optimistic would say that we must do better.

The daunting task of this conference is to move beyond endorsing sustainability in principle and to obtain political traction to influence transportation policy and activities. Mr. Deen provided the conference participants with some optimism. While a single definition of sustainability eludes diverse groups, it is not the first powerful concept that suffers from the lack of a precise definition. Precise definitions also elude art and religion, but progress in these areas has been made. Soon a point will be reached where even critics will see the limits of the earth's resources and man's effects on them, and change will be forced.

The job of the conference participants is to figure out how to put sustainability objectives into the real world and make changes. It is necessary to be prepared for the time when crisis demands ideas that can be implemented.

Presentations on Transportation Sustainability Indicators

Mark DeLuchi, *University of California* (presented by David L. Greene, *Oak Ridge National Laboratory*)
Mike MacCracken, *Climate Institute*
Daniel Sperling, *University of California, Davis*
David G. Burwell, *Prague Institute for Global Urban Development*
Elizabeth Deakin, *University of California, Berkeley*
Richard Forman, *Harvard University*

Health

Mark DeLuchi

David Greene presented on behalf of **Mark DeLuchi,** who was unable to attend the conference. The presentation, External Costs of Motor Vehicle Use: Status and Trends, discussed transportation's external costs as well as its impacts on human health. The external costs examined in the presentation included accidents, congestion, oil use and energy security (military expenditures, macroeconomic costs, pecuniary costs), air pollution (human health, visibility, crops, forests), and noise. The presentation provided estimates of these costs as well as trends in impacts and costs.

Since 1990, all of the external costs of transportation except those resulting from air pollution have increased substantially. The cost increases have occurred because of a steady increase in vehicle miles traveled despite some areas of improvement such as a reduced involvement of alcohol, increased use of seat belts, and improved vehicle safety. The difficulty of reducing the growth of vehicle miles traveled suggests that health, safety, noise, congestion, and energy security costs of motor vehicle use may have to be mitigated by reducing impacts per mile. Such mitigation, however, faces many challenges, and it is not likely that spotty management of per mile impacts will result in a sustainable transportation system.

Transportation sustainability depends on the development of personal transportation choices that reduce the externalities of transportation without compromising any of the benefits of private motor vehicle use. This will require new visions of integrated development of towns, transportation infrastructure, and transportation modes.

Climate Change

Mike MacCracken

Mike MacCracken began his presentation, Climate Change and Sustainable Transportation: The Need to End Our Addiction to Fossil Fuels, by dividing the climate change issue into the following three questions:

1. How is the climate expected to change, and are we already seeing the early signs of these changes?
2. What are the likely environmental and societal impacts of changes in carbon dioxide concentration and the climate, and to what extent can adaptation ameliorate the projected negative consequences?
3. What are the options for limiting the human-caused factors inducing these changes, and how rapidly and economically can they be implemented?

Answering these key questions is complicated by several unusual factors including long time horizons; the fact that all that can be expected given the complexity of society and the environment is a projection of a range of possibilities; and the fact that the causes, impacts, and control of the climate change issue are necessarily international. Dr. MacCracken then summarized fossil fuels' benefits to society as well as the major effects they have on the environment. He demonstrated that the rise in

carbon dioxide concentration is unusual and that average temperatures are in fact higher because of human activity. Other climate measures are projected to change because of fossil fuel use: precipitation and the rate of evaporation will increase and sea level will rise. It is important to be aware that changes in these measures may not be smooth; abrupt changes are possible.

Adaptation will be essential regardless of choices made concerning mitigation. Past emissions have already initiated climate change, and implementation of mitigation will merely determine the rate of climate change. With regard to the impacts of climate change on particular regions, only generalized projections are possible. However, tools have been developed to indicate levels of likelihood and confidence, and particular regions and sectors should use these tools to enhance long-term planning.

The presentation concluded with the message that transportation is not only responsible for emissions of greenhouse gases but will also be affected by the changing climate. To be sustainable, the transportation system must address adaptation as well as mitigation.

Energy

Daniel Sperling

Daniel Sperling's presentation on transportation energy sustainability began by outlining the upward trends in energy use and greenhouse gas emissions. Rapid increases in worldwide energy use are expected to continue, and carbon dioxide emissions are increasing, with an increasing proportion from transport.

Potential methods to reduce greenhouse gas emissions and oil use were discussed. Suggestions included changes in behavior such as driving less and use of efficient, low-carbon modes of transportation; changes in transportation and land use formats such as new modes (car sharing, smart paratransit, dynamic ridesharing), specialized vehicles, and more efficient land use patterns; and changes in technology and fuels such as more energy-efficient vehicles and use of low-carbon fuels. Large reductions in greenhouse gases are possible with electric drive and alternative fuels. Although previous alternative fuels, such as synfuels, methanol, ethanol, and compressed natural gas, failed because of cost and lack of large societal benefits, more promising alternative fuels such as cellulosic ethanol, battery electric vehicles, and hydrogen fuel cell vehicles have high efficiency and reliability and zero to near-zero emissions.

Dr. Sperling recommended that signals be sent to consumers and industry to reduce energy consumption and greenhouse gases. More efficient use of transport, improvements in conventional vehicles and hybrid electric vehicles in the near term, and longer-term investments in advanced technologies should be encouraged. Research into and development of clean and renewable energy sources should be expanded, as should experimentation with new vehicles and services.

Equity

David G. Burwell

David G. Burwell discussed the relationships between equity, social stability, and sustainable transportation. Traditionally, the equity and social issues of transportation were thought to affect only the poor. More recently, however, these issues have been recognized as affecting a much broader range of the demographic, including low-income and minority groups, seniors and the elderly, children, and the physically disabled. The extent of the impact also is much broader and includes access to transportation services, lifestyle (active versus sedentary as well as social isolation), and community cohesion. Community cohesion is required to be considered in all transportation plans and is defined by the extent of civic institutions, trust of political institutions, density of acquaintances, and degree of family and friendship networks.

The equity and social impacts of transportation place challenges on transportation planning. The challenges will require better planning management that accommodates notions of social equity across population groups with respect to access, quality of life, and community cohesion. Current transportation services, in conjunction with present settlement patterns, generate too many social burdens and insufficient social benefits across interest groups.

People have been designed out of many urban areas, which contributes to increases in obesity, increases in Type 2 diabetes in minority children, reductions in the independent mobility of children (e.g., parents must drive children to school), and reductions in senior citizen travel. Transportation, if properly planned, could build social stability by renewing neighborhoods, nurturing a sense of community, improving safety and security, improving access, promoting public health, and shaping growth to minimize sprawl.

The following activities should be undertaken to move toward including the impacts on equity and social stability in transportation planning:

- Study community cohesion as a planning factor, as required by 23 U.S.C. 109(h)(2);
- Improve accountability of agencies and community partners in addressing transportation, equity, and social stability;

- Place intense focus on community engagement in all planning efforts to understand equity and social stability impacts; and
- Strengthen transportation and land use partnerships as a primary strategy for good equity and social stability outcomes.

Land and Community

Elizabeth Deakin

Elizabeth Deakin began her presentation on land use, development, and sustainable transportation by highlighting key strategies for sustainable development and transportation in urban, suburban, and rural areas. The following are among the key strategies for sustainable urban and suburban development:

- Investment and reinvestment in existing districts and neighborhoods, including preservation, renovation, and reuse of structures;
- Upgrades to infrastructure (sewer, water, streets and highways, telecommunications, parks);
- Upgrades to services (schools, police, fire);
- Development of higher-density communities, especially near transit;
- Development of mixed-use real estate, especially in downtowns and city centers; and
- Infill of urban areas to create contiguous growth.

These urban and suburban development strategies should be coupled with transportation strategies such as sidewalk improvements, transit service improvements, signal timing favoring person trips rather than vehicle movements, and clean and well-paved streets.

In rural areas, the key strategies for sustainable development are slightly different and include the following:

- Preservation and renewal of main streets and village centers;
- Preservation of rural landscapes and views;
- Conservation of agriculture and open spaces;
- Cluster development; and
- Economic development and job training to maintain, increase, diversify, and improve jobs.

As with urban and suburban areas, rural sustainable development strategies should be coupled with transportation strategies as follows:

- Traffic calming on entering towns,
- Sidewalks and bike lanes in towns and walking trails and bike paths through the countryside,
- Road location and design that take advantage of scenic vistas and historic sites and that protect environmentally sensitive areas, and
- Road ecology.

The following are among the challenges facing sustainable transportation and development:

- It is easier to keep doing what you know than to try something new.
- Reuse, rehabilitation, renovation, and infill can be costly and may generate opposition.
- Infrastructure provision, pricing, and funding policies sometimes favor new areas.
- Design standards for arterials and highways emphasize vehicle throughput to the detriment of other street functions.
- Funding for sidewalks or street trees is lacking.
- It is difficult to meet transportation needs in low-density suburbs and rural areas for those without cars.
- There is not enough funding for operations and maintenance.

Despite these challenges, successes are found all over the country. The successes, however, are not yet translating into an overall development trend. Some regions are building on project successes to devise a regional strategy, and some state departments of transportation are reforming their policies to integrate land use and community values.

The differences between the success stories and the stories of those who have tried and failed were summarized. Environmental quality, equity, and economic development are fundamental objectives of planning processes, not post hoc evaluation criteria. In instances of success, planners are not just forecasting but also backcasting to figure out how to get to a future that people want.

Habitats and Ecosystems

Richard Forman

Richard Forman began his presentation by stating that the objective of sustainable transportation with regard to habitats and ecosystems should be to mesh safe and efficient mobility with natural processes and biodiversity. Society should aim to improve natural systems along the road network while reestablishing a connectivity of natural areas and green corridors that the road network has cut into small parcels. The presentation then focused on seven aspects of road ecology:

1. *Road kill*. This is generally a minor issue exception when animals that reproduce slowly are affected.

2. *Traffic disturbance and wildlife*. A study was discussed that found that low-volume roads do not have any statistical effect on the breeding or existence of birds surrounding the roadway. As volume on roads increases, however, the study showed a significant effect on the breeding and existence of birds. The size of the affected area also increases as traffic volumes increase. Solutions to the impacts of traffic on wildlife may include improved vehicle and pavement designs that reduce noise.

3. *Roadside vegetation*. A primary function of roadside vegetation is safety. If roadside trees narrow the vision ahead, drivers slow down. Roads in the United States, however, are designed for speed, with grassy open areas along the roads. Trees planted up to the side of the road could improve safety by reducing speeds and at the same time provide habitat for wildlife.

4. *Connectivity of land*. The existing road network severs the land and affects the habitats and migration patterns of wildlife. Overpasses to increase connectivity, not only for animals but also for farmers and hikers, should be used.

5. *Water and aquatic ecosystems*. Sedimentation, road salt, and other pollutant runoff from roads affect water quality. Such impacts, however, can be mitigated by disconnecting roads from water bodies and by using soil as a filtering substance for runoff.

6. *Road density*. The current road network's insensitivity to ecology was discussed, and an ecosystem-friendly transportation infrastructure that maintains large road-free areas and concentrates traffic on a few large roads was described.

7. *Regional transportation planning*. Currently, air quality is the only environmental impact of transportation that is adequately modeled on a regional basis. Similar modeling should be conducted for other major environmental issues.

Concurrent Sessions
What Are the Challenges?

William R. Black, *Indiana University*
Joan Ogden, *University of California, Davis*
Michael Wang, *Argonne National Laboratory*
Kevin E. Heanue, *Consultant*
Bob Johnston, *University of California, Davis*
John P. Poorman, *Capital District Transportation Committee, Albany*
Arthur (Chris) Nelson, *Virginia Polytechnic Institute and State University*
Steve Lockwood, *PB Consult*
Tom Sanchez, *Virginia Polytechnic Institute and State University*
Christina Casgar, *U.S. Department of Transportation*
Lee Schipper, *World Resources Institute*
Martin Lee-Gosselin, *University of Laval, Canada*

This section provides a synthesis of the presentations and discussions that occurred in the initial sessions of four concurrent sessions on the following topic areas: technology, tools and institutions, policy, and behavior. In each concurrent session, two presentations were followed by a facilitated discussion. The purpose of the initial concurrent sessions was to discuss the challenges facing sustainable transportation in each of the four topic areas.

Concurrent Session I-1: Technology

William R. Black, Facilitator
Joan Ogden and Michael Wang, Presenters

Presentations

Joan Ogden discussed the potential role for hydrogen in a sustainable transportation system. She outlined several reasons why hydrogen should be considered as a transportation fuel, including its zero or near-zero emissions at point of use, low to zero well-to-wheels emissions of both air pollutants and greenhouse gases with some supply pathways, ability to be made from diverse sources (fossil, renewable, nuclear), wide use today, the rapid progress in hydrogen and fuel cell technologies, and potential to enable new products and services that would transform the way energy is used and produced. In addition, hydrogen could reduce greenhouse gas and air pollutant emissions and utilize diverse energy supplies.

Barriers to a hydrogen economy include the need to develop emerging technologies while adapting current hydrogen technologies for a hydrogen energy economy (e.g., fuel cells, hydrogen storage for vehicles), the current high cost of hydrogen end use technologies, the current lack of infrastructure to deliver hydrogen to consumers, and the lack of consistent policies reflecting the external costs of energy. Hydrogen also presents technical challenges. For instance, current automotive fuel cells are many times more expensive than gasoline, the lifetime of fuel cells is currently too short, there are unresolved system issues with heat and water management, hydrogen is bulkier and heavier than liquid fuels, and no current hydrogen storage technology satisfies automobile company requirements with regard to cost, range, and refueling time. The technology to produce hydrogen at a large scale and low cost from fossil fuels

is well established. Small-scale production of hydrogen at refueling sites, however, is under development and is facing issues such as cost, efficiency, and system integration. For hydrogen to be sustainable, pathways must be zero carbon and zero emissions.

Even under optimistic scenarios, it will be several decades before hydrogen can affect emissions on a global scale. Dr. Ogden recommended the following actions to support hydrogen: research and development on hydrogen technologies, public–private partnerships to demonstrate hydrogen technologies, the institution of federal and state governments as early adopters of hydrogen technologies, the establishment of codes and standards for safe operation in energy applications, and analysis to better understand the societal costs of energy and the role of hydrogen in the future energy system.

Michael Wang discussed the life-cycle effects of vehicle and fuel technologies. The gap between U.S. oil demand and domestic oil supply will continue to grow, new-vehicle fuel economy in the United States has not improved measurably since 1985, and the United States will continue to have the highest total greenhouse gas emissions. The reduction in criteria pollutant emissions has been a bright spot in the United States.

The life cycle of fuel can be defined as "well to wheels" or "well to pump + pump to wheels," and the entire life cycle needs to be considered in energy and environmental assessments. Oil use and greenhouse gases are major challenges for a sustainable transportation system. However, efficiency improvements, combined with fuel switches, could significantly reduce oil use and greenhouse gas emissions of motor vehicles. As tailpipe emissions continue to decline, well-to-pump emissions of criteria pollutants could become a significant share of total well-to-wheel emissions, and this portion of the life cycle should not be ignored. Advanced vehicle and fuel systems need to be carefully examined to ensure achievement of intended energy and emission benefits.

Discussion

After the two presentations, William Black facilitated a discussion. Topics included ways in which hydrogen might interact with other infrastructure and trends, the need to design transportation infrastructure now for future hydrogen compatibility, and the ability to apply transportation planning tools to the hydrogen economy. The need for technological change must be communicated effectively to the public. To motivate political action, a global understanding of the long-term problem and the need to make decisions now to affect results 50 years in the future is necessary.

Concurrent Session I-2: Tools and Institutions

Kevin Heanue, Facilitator
Bob Johnston and John Poorman, Presenters

Presentations

Bob Johnston discussed the sustainable transportation planning tools available to metropolitan planning organizations and state departments of transportation. Current sustainable transportation planning is a medium-range process that ignores most impacts. A policy analysis framework that requires long-range comprehensive planning should be developed and implemented.

Once such a policy framework is in place, existing tools and models can be used to facilitate the sustainable transportation process. Within agencies possessing adequate resources, there is a technical capacity to engage in land use and transportation modeling. Dr. Johnston provided an overview of models currently in use throughout the United States and noted the cost-effectiveness and appropriate scale of use of each model.

John Poorman offered insight into the current state of transportation planning's institutional framework and culture. Missed opportunities in the sustainable transportation movement were discussed. The recent transportation funding reauthorization debate was one such missed opportunity to promote sustainability in transportation.

The current institutional structure for transportation planning is capable of supporting sustainable planning. However, the institutional culture of planning organizations inhibits advancement toward the integration of sustainable concepts. Transportation planning is a slow process that is constantly in transition. There is a lack of institutional understanding about the future and a need for metropolitan planning organizations and state departments of transportation to embrace uncertainty in the planning process.

Metropolitan planning organizations and state departments of transportation must approach transportation planning as a multipurpose process and not limit their perspective to only one mode. Finally, long-range transportation planning and community formation and land use planning require improved funding.

Discussion

Kevin Heanue facilitated this session's discussion. The discussion focused on the many challenges facing the implementation of planning tools and models within the

sustainable transportation movement. The discussion identified the following issues:

- Lack of a sustainability requirement in the planning process;
- Cultural resistance to the sustainability movement;
- Lack of resources for the sustainability movement;
- Existence of political pressures;
- Lack of accountability within the transportation planning process;
- Lack of performance measures;
- Variation in forecasting methods—state, local, and federal;
- Differences in metropolitan economics and governing;
- Overemphasis on model running and lack of emphasis on data feeding; and
- Difficulties in modeling equity impacts.

Concurrent Session I-3: Policy

Arthur (Chris) Nelson, Facilitator
Steve Lockwood and Tom Sanchez, Presenters

Presentations

Steve Lockwood mentioned some of the challenges facing policy with regard to sustainability. They include positional/political sustainability, institutional/financial sustainability, program sustainability via accountability (i.e., systems development, output efficiency, and mobility and safety outcomes), and environmental sustainability (i.e., regulatory requirements and program externalities). To complicate matters further, sustainability goals encompass several overlapping policy arenas including technology, demand management, and supply management. In addition, issues of sustainability lie within the span of control of all levels of government—federal, state, regional, and local.

Mr. Lockwood discussed the role of system operations in a sustainable transportation system. He summarized the effect of system operations and management on roadway operating regimes for both recurring and nonrecurring causes of delay. In general, potential reductions in delay are minimal except for incident management of breakdowns and crashes. In that case, a reduction of 20 percent is possible. With regard to the impact of operations on emissions, even the most cost-effective emission reduction strategies do little for mobility or congestion (except pricing).

Trends in system operations were discussed, including reductions in system expansion coupled with a focus on the efficiency of available capacity, significant improvements in speed–flow regimes, improvements in safety and security, reductions in modal distinctions, and possibly the integration of operations into the planning process. Transportation providers are moving from providing a network and developing projects to improving mobility through system operations and management.

Tom Sanchez discussed the equity considerations and concerns of sustainable transportation. From a research perspective, it is important to identify the constraints that prevent people from participating adequately in all aspects of society, including education, employment, housing, and public services. There are several areas of concern in transportation equity research: demographic trends, personal transportation costs, indirect economic and social effects, health effects, language barriers, citizen participation, and employment and business opportunities within the transportation industry.

Discussion

After the two presentations, Arthur Nelson summarized the statistics of anticipated development over the next 30 years and the implications that this development may have for highways. Among the implications are increased vehicles, vehicle miles traveled, and lane miles. He posed the following policy questions:

- Where should this development be built?
- How should this development be configured?
- How should transportation systems be designed to serve this future development?
- What policies and policy processes are needed to achieve this at the federal level?

Among the policy challenges facing sustainable transportation are the lack of broad consensus on national targets for sustainability; the absence of nationally galvanizing goals for sustainability; and the lack of broad public understanding of the issues, challenges, choices, and implications of choices with regard to sustainability.

Concurrent Session I-4: Behavior

Christina Casgar, Facilitator
Lee Schipper and Martin Lee-Gosselin, Presenters

Presentations

Lee Schipper addressed the role that behavior plays in achieving sustainable transport. He focused on the role

that the United States plays in shaping the worldwide view of sustainable transport and the steps being taken toward implementing sustainable transport in the United States.

Unpredictable changes in behavior hamper the sustainability process. Intervention could enable the sustainable transportation movement at three levels of behavior: the macro level (politicians), the meso level (administrators and transport professionals), and the micro level (individual travelers).

Key areas where further research is needed linking transportation and behavior were identified. There is a need for a shift from typical destination studies to an analysis of the transportation decision-making process. To achieve sustainable transport in the United States, Americans need to develop cultural recognition and cost internalization of the basic ingredients of sustainability.

Martin Lee-Gosselin discussed the reasons behavior is seen as a problem in sustainable transportation planning and policy. He also spoke to ways researchers are responding to the complexity of evolving transportation behavior.

Dr. Lee-Gosselin first defined the externalities and unanticipated consequences (good and bad) that result from the choices of travelers. He then described the six inconveniences of behavior, including the difference between preference and choice and the complexities that arise from the fact that mode and route choices depend on more than just a traveler's work commute.

Several short- and long-term actions being taken by researchers to address the complexity of behavior were identified. It is helpful to understand which decisions are important to whom (individuals, firms, public agencies). There is a need to understand both conventional data sources and how travelers interpret and use information on travel options.

Dr. Lee-Gosselin proposed that the transportation industry design behavior indicators and establish a balance between persuasion, pricing, and regulation. Behavior change in favor of sustainable transportation will require feedback at the local, regional, and national levels.

Discussion

Christina Casgar facilitated the discussion during this session. The discussion focused on the limitations of human cognitive ability and how these limitations affect the planning process. The inability of the individual to grasp the idea of sustainability was attributed to the restriction of thought to short-term versus long-term thinking. The participants also made an attempt to determine the extent to which changes in behavior had to occur before changes in transportation could be achieved.

Reports on the Concurrent Sessions
What Are the Challenges?

Genevieve Giuliano, *University of Southern California*
Thomas M. Downs, *Eno Transportation Foundation*
Anne Canby, *Surface Transportation Policy Project*
Richard Gilbert, *Centre for Sustainable Transportation*

Conference participants assembled in a general session to discuss key points and areas of general agreement identified in the initial concurrent sessions on the challenges facing sustainability in each of the four topic areas: technology, tools and institutions, policy, and behavior. A rapporteur provided an overview of each initial concurrent session.

Concurrent Session I-1: Technology

Genevieve Giuliano, Rapporteur

Participants primarily discussed the technology of future energy sources with regard to production, distribution, and storage. A 30- to 70-year time frame is required for the implementation of new transportation technologies. To make informed policy decisions about future energy sources and their sustainability, a full "well-to-wheel" evaluation is required.

In the short term, future energy sources are likely to include hybrids, natural gas, ethanol, and unconventional oil. In the long term, hydrogen appears to be the most promising energy source, but other options such as nuclear, electric, and sequestration also need to be considered. Hydrogen has the most potential, on the basis of its diverse sources of production, near-zero emissions, and rapid technological advances. The technological challenges associated with hydrogen include its high cost, limited fuel cell lifetime, heat and water management, on-vehicle storage, production systems, and risk and uncertainty of some production sources. The transition to hydrogen also presents such obstacles as consumer acceptance and development of compatible production, storage, and distribution systems. Whether to produce hydrogen from fossil fuels as an interim phase to production via electricity is another question.

In addition to the development of future energy sources and the reduction of greenhouse gases, areas where technology could be successful in meeting sustainable transportation challenges include adaptation to climate change, improved safety, noise reduction through sound-absorbing pavements and quiet cars, congestion relief through improved system management, and facilitation of mobility. The participants concluded that technology research should be focused where solutions are the most promising with regard to their positive impact on sustainability.

Concurrent Session I-2: Tools and Institutions

Thomas M. Downs, Rapporteur

Participants discussed numerous challenges to integrating concepts of sustainability into the tools and institutions of the planning process. To start, sustainability is not a requirement in the planning process, and political pressures and a lack of resources inhibit the movement toward sustainability.

Additional challenges are a lack of accountability in planning organizations; the absence of performance measures; the variety of forecasting methods across fed-

eral, regional, state, and local levels; a culture of being in the lead rather than a culture of collaboration; differences in metropolitan economics and governing; overemphasis on model running and lack of emphasis on data feeding; absence of a 50-year planning requirement; inability to assess equity or public involvement; lack of cross-disciplinary training; and the need to establish sustainability as an important issue at the national level.

Concurrent Session I-3: Policy

Anne Canby, Rapporteur

The participants in this session discussed how to set priorities, fund programs, and establish rules to implement policy that furthers the goal of sustainable transportation. The lack of a uniform definition of sustainability combined with the complexity and uncertainty of the issues limits the ability to address these issues. The importance of credibility in engaging others and garnering broad support for the issues of sustainability was also discussed. Surrogate issues can be used to reach desired outcomes with regard to some aspects of sustainability such as climate change. The building of coalitions around these issues will develop support for sustainability that can be drawn on when the time is right for policy development. It should be possible to build support for change in the following areas:

1. Energy availability at a reasonable price,
2. Safety,
3. Health (asthma, obesity),
4. Environment (ecosystems, biodiversity, air and water pollution), and
5. Equity.

The participants discussed congestion and mobility in addition to the fives areas listed above but questioned whether these issues fit within the framework of sustainability.

Flexibility in the transportation system and its institutions is important, since it is not known what will trigger the need to address sustainability. Currently, the transportation system and its providers are not prepared to address sustainability. Institutional and financial rigidities prevent steps toward sustainability from being taken. The session participants discussed the need for better ways to measure project and agency performance, fiscal flexibility to enable addressing changing circumstances, and coalitions to build the conditions to address solutions.

Concurrent Session I-4: Behavior

Richard Gilbert, Rapporteur

Participants discussed approaches to behavior (i.e., what people do), whether they are travelers, shippers, decision makers, or others. Two general approaches were described. One is the Confucian approach, also embraced by American behaviorists, which looks for the causes of behavior in the environment or context in which it occurs. The other is the Aristotelian approach, which holds that behavior is the result of people's choices, the product of will or mind. Confucians would change behavior, if they were so inclined, by changing its circumstances or consequences. Aristotelians seek to change behavior by persuasion, perhaps backed up by changes in its context. The limited evidence concerning what it takes to change transport activity suggests that Confucians may have better answers. Desirable outcomes are more likely to be achieved by judicious use of incentives and disincentives and by otherwise structuring environments to favor what is required than by convincing people that change is necessary.

Five challenges were identified:

1. Giving appropriate feedback. Transport indicators are not good enough to support provision of effective consequences of good or bad transport activity.
2. Achieving effective balances of regulation, pricing, and persuasion. Each has its role.
3. Recognizing that transport behavior is among the most complex things that people do.
4. Recognizing the importance of the meso level (i.e., administrative and expert behavior) versus the macro level (politicians) and the micro level (travelers and shippers).
5. Coping with longer time scales (i.e., beyond the next fiscal year).

Participants identified 12 research areas related to behavior and sustainability:

1. Determining the extent to which it is necessary to change hearts as well as heads;
2. Empowering stakeholders;
3. Establishing the importance of alternatives;
4. Understanding individual transport behavior better;
5. Understanding freight trends and who is responsible for them;
6. How to get at kids in school, from kindergarten to Grade 12;
7. Operationalizing meso planning;

8. Developing indicators of necessary versus discretionary change;
9. Making use of fairness in transport planning;
10. Making better use of natural experiments;
11. Determining a "reasonable level of mobility"; and
12. Integrating environmental management and transport management at regional levels.

Panel Discussion
Potential Solutions to Challenges

Kevin E. Heanue, *Consultant* (Moderator)
Anne Canby, *Surface Transportation Policy Project*
John Horsley, *American Association of State Highway and Transportation Officials*
Hal Kassoff, *Parsons Brinckerhoff*
John Pucher, *Rutgers University*
G. Alexander Taft, *Association of Metropolitan Planning Organizations (retired)*

On the second day of the conference, a roundtable discussion was held by a distinguished panel. The participants discussed potential solutions to the sustainability challenge.

Anne Canby indicated that her view of sustainability includes the minimization of environmental degradation, the minimization of energy consumption, the strengthening of communities and their residents to self-sufficiency, and the reduction of public and personal health risks from transportation. Sustainability requires examining transportation in a broader context that gets beyond a project perspective.

Approaches for redirecting transportation investment toward sustainable objectives were outlined. Approaches dealing specifically with the planning process included the creation of valid planning processes in state highway agencies; the expansion of the long-range planning process to include collaboration and integration with energy, environment, public health, and community development policies; and the integration of operations and services/modes in the planning process. Collaboration with public stakeholders should be expanded during planning before projects have been identified, and measures of sustainability should be incorporated into the National Environmental Policy Act process.

Two of the approaches deal specifically with funding. Ms. Canby recommended a change in the factors used to distribute federal funding and in the way public-sector transportation investment is funded. The decision-making authority over how to allocate funds among state highway agencies, regional transit operators, and regional planning entities should be shared.

Among other approaches are broadening the transportation perspective to encompass desired outcomes in nontransportation areas as well as transportation, explicitly including strategies to reduce accident rates and fatalities and reward those who reduce accidents, and changing the way priorities are set to incorporate urban revitalization and minimization of land consumption.

John Horsley summarized the situation facing state departments of transportation (DOTs). State DOTs do not have the resources to meet requested mobility needs. They are unable to buy right-of-way because it is already developed, they cannot build the network of highways that the current development pattern expects of them, and they cannot generate the resources to maintain the existing network.

Advocacy for sustainable transportation must come from the grass roots. Participation in conferences like this should be broadened to include the land use community, citizen activists, the developer community, and city and county officials with land development responsibility. Given the current market, where developers are reporting greater sales per foot from urban development than from big box retail shopping centers, the engineering solution to transportation cannot be the only answer.

The U.S. Department of Transportation should collaborate with other federal agencies, including the Department of Housing and Urban Development, the Department of Energy, the Department of Commerce, and the Environmental Protection Agency. These federal institutions need to break down silos to address the crosscutting issue of sustainability.

Hal Kassoff began by discussing whether the concept of sustainable highways is an oxymoron or an opportunity. Highways are typically viewed as part of the problem and labeled antisustainable, whereas transit, freight railroads, bicycling, and walking are parts of the solution. Vehicles, however, can be made more sustainable through alternatives to fossil fuels, and similarly, there are opportunities to make the highway infrastructure part of the solution.

Most state DOTs embrace environmental stewardship and agree that while meeting functional requirements is the primary objective, it is not the only objective. Meeting the functional requirements while being environmental stewards results in sustainable highways. In addition, most highway projects are improvements to existing roads. Since the existing roads were not built in accordance with today's demanding environmental standards, such projects present opportunities to meet the current stringent environmental and equity requirements. There are significant opportunities for highway infrastructure to help meet sustainability objectives in the areas of noise, water quality, ecology, equity, recycling, safety, and mobility.

A possible definition for sustainable highways is "highways that, from conception to completion, through maintenance and operations, satisfy life-cycle functional requirements while improving the natural, built, and social environment." Highways will remain an enduring component of our transportation system with a recurring need for rehabilitation, reconstruction, and, at times, expansion. Rehabilitation, reconstruction, and expansion projects present opportunities for improving not just the functionality of highways but their ability to contribute to sustainability goals.

John Pucher began by questioning what is meant by mobility. It is important to distinguish between mobility and access. There is a trade-off between mobility and sustainability, whereas it is possible to provide sustainable accessibility. With regard to mobility, the transportation system of the United States is reaching a point of diminishing returns. The focus should be on providing better accessibility as opposed to more mobility. Current lifestyle and land use patterns are addicted to mobility, but Dr. Pucher questions how much mobility will be enough.

Dr. Pucher also discussed the apparent dismissal of walking and biking as modes of transport. These modes, which are often ignored by planners and engineers, are perfect from a sustainability perspective and need to be taken more seriously. A broader view should be taken of health problems related to transportation. Personal health is a major component of the sustainability solution, and individuals should be encouraged to walk and bike for purposes of their health. Walking and biking also increase social interaction and independence. True intermodalism is required for sustainability. Intermodalism would coordinate all modes and integrate walking and cycling with other modes enabling longer trips.

Alex Taft provided his perspective on metropolitan planning and sustainability. The two keys to moving toward sustainable transportation are a planning process infused with public participation and the development of an overarching vision for the community. Comment periods should be extended, all neighborhoods and businesses should be involved, and consensus should be reached on a plan that has strategies and projects consistent with its theme and objectives. All projects, including nonmotorized and transit projects, should be prioritized in conformance with the plan's theme and objectives.

To avoid simply continuing what has been done in the past, public participation must be improved. It is important to demonstrate how public participation changed the plan. In addition, metropolitan planning organizations must work with the community to develop an overarching vision for the area that integrates concepts of land use, environmental protection, and energy conservation.

Reports on Concurrent Roundtable Discussions
Potential Solutions to Challenges

Genevieve Giuliano, *University of Southern California*
Thomas M. Downs, *Eno Transportation Foundation*
Anne Canby, *Surface Transportation Policy Project*
Richard Gilbert, *Centre for Sustainable Transportation*

Conference participants assembled in a general session to discuss key points, areas of general agreement, and areas for further research identified in the concurrent sessions on the potential solutions to the challenges in each of the four topic areas: technology, tools and institutions, policy, and behavior. These concurrent sessions were conducted in roundtable format. A rapporteur provided an overview of each concurrent session.

Concurrent Session II-1: Technology

Genevieve Giuliano, Rapporteur

Participants discussed whether there was a role for technology in each of the dimensions of sustainability. For each dimension in which technology could have a role, the participants discussed how strong that role could be, what policies are needed to implement the role, and at what level of government the responsibility for that technology would reside. Technology was determined to have a major role in the areas of future fuels, greenhouse gases, air pollution, safety, and noise. Technology was seen to have a medium role in the areas of mobility and congestion and a small role in biological impacts and equity.

The session participants concluded with three major points. First, aggressive research and development across an array of technologies are needed to meet the sustainability goal. Second, there is a need for research and development and policy analysis to prepare for future fuel transition. Finally, adaptation to climate change and its impacts on the transportation system should be incorporated into the transportation planning process as soon as possible.

Concurrent Session II-2: Tools and Institutions

Thomas M. Downs, Rapporteur

The discussion focused on finding solutions to several of the challenges raised in Concurrent Session I-2. The group discussed the need for a national initiative that recognizes and legitimizes sustainability in planning. The slow pace of change within the federal government and its impacts on achieving sustainable transportation were also discussed. The difficulty faced in the recent transportation funding reauthorization is a prime example of this slow pace of change.

Primary challenges brought to light as a result of Concurrent Session I-2 include cultural resistance within institutional planning agencies and the lack of a national initiative legitimizing the sustainability movement. Participants discussed how the existing institutional structure is capable of facilitating sustainable transportation planning within local, regional, and state planning agencies. It is believed that the systems of decision making and allocation are in place to allow for change within the planning process and that governments have the flexibility and the jurisdiction to integrate sustainability into the current framework. A lack of understanding about what practices work and do not work, however, has created a cultural resistance to the inclusion of sustainability considerations in the planning process.

The participants recommended that a best practices handbook be compiled and issued to transportation professionals. It also was suggested that a sustainability training program be established for transportation planners. The participants expressed a need to establish sustainability at the national level. The group recommended that sustainability issues be tackled via pilot projects and real-world experiments. The development of sustainability standards and a quantification of both the benefits and the negative aspects of sustainability were encouraged. The implementation of these practices would be steps toward legitimizing the sustainability movement.

Concurrent Session II-3: Policy

Anne Canby, Rapporteur

The participants discussed the changing housing market and how the current trends for urban higher-density living will shape the future of transportation. They also noted that federal, state, and regional levels of government all must play significant roles in policy initiatives.

To address sustainability concerns, the participants encouraged policy development in the following areas:

- Broaden curricula to cover demands that will be placed on future planners and transportation professionals, including the addition of human sciences to the engineering curriculum.
- Perform research into how mode choice, vehicle use, and energy consumption change with respect to density, location, and land use configuration given changing demographic trends, residential preferences, and office–retail dynamics.
- Facilitate market forces favoring transportation sustainability.
- Establish an interdepartmental working group on sustainability (including the Department of Housing and Urban Development, the Department of Energy, the Environmental Protection Agency, the Department of Treasury, and the Department of Health and Human Services, among others).
- Create a national dialogue and build consensus on the need for sustainability.
- Identify the barriers within institutions and policies to achievement of a sustainability program.

Concurrent Session II-4: Behavior

Richard Gilbert, Rapporteur

The complexity and the limitations of human cognitive ability, which may underscore inability to engage in long-term decision making, were discussed. Several issues deemed to be important to the sustainability movement were thought to have been overlooked in the planning process. Two examples of unaddressed issues are (*a*) consideration of the time scale needed for longer-range planning and (*b*) insufficient provision of information to people affected by the planning process. Achieving balance between regulation and pricing also was seen as critical to attaining sustainable transportation. Finally, the participants emphasized the importance of identifying the appropriate level or group within the transportation planning process to lead the movement toward sustainability.

Several educational and technical initiatives were identified as solutions to some of the challenges. Emphasis was placed on the use of training and education to change human behavior. Children and transportation professionals were cited as target groups for educational initiatives. The possibilities for expanding the planning process to create a more inclusive atmosphere were also discussed. The planning process must engage hitherto unrepresented and underrepresented groups, including industry. Improved dialogue between government and industry must be encouraged.

In previous sessions, expansion of the transportation planning process had been cited as critical to the successful integration of sustainability. It was agreed that expansion could involve several components, including visioning. The designation of funds for the visioning process at the metropolitan and state levels is necessary for its implementation. Finally, it was recommended that transportation professionals include operations and capital investment issues in the transportation planning process.

The group emphasized the need to build a consciousness of sustainability and discussed a strategy for achieving this goal. A hierarchy of implementation was formulated as a guide toward attaining sustainability. It was suggested that modules of sustainable education be introduced at all levels of education, beginning with elementary school. Participants recommended that assessments of staffing and educational needs be conducted at the state and metropolitan levels. Implementation of a cost assessment strategy aimed at fully costing sustainable and nonsustainable transport was also recommended. The level appropriate for intervention—that is, the group through which to push change—was determined to be the meso level: experts and bureaucrats. The meso level could assist in making behavior changes in the macro level of politicians and at the micro level of individual travelers. The retraining of the meso group could help promote sustainable behavior among the users and regulators of transportation.

In summary, the breakout group identified 10 solution areas:

1. Focus on educating children for sustainability, both as transport's "canaries" and as adults-to-be.

2. Focus on the training of engineers and other transport professionals in sustainability.

3. Have empty seats in the planning process (say, an older person, a Bangalore resident, and a fish).

4. Require a visioning element as part of the metropolitan planning organization process; designate a set share of funds, say 7 percent.

5. Prepare a casebook of good and bad practices, mainly for educational purposes.

6. Prepare a casebook of good and bad situations (for example, which contexts sustain transit use and which do not).

7. Require transport planning processes to consider full-cost pricing.

8. Provide federal resources for more, different, and better staffing of metropolitan planning organizations.

9. Involve industry in planning for transport sustainability (e.g., hold a conference for chief executive officers).

10. Expand the metropolitan planning organization process to deal with operations issues as well as capital investment.

Luncheon Speakers

Lewis Dale, *General Motors*
Emil Frankel, *U.S. Department of Transportation*

Lewis Dale offered luncheon remarks to participants on the first day of the conference, and Emil Frankel offered remarks on the second day. A summary of each speaker's remarks follows.

Lewis Dale discussed the final report of the World Business Council for Sustainable Development's Sustainable Mobility Project. *Mobility 2030: Meeting the Challenges to Sustainability* reflects the collective efforts of more than 200 experts from a broad set of 12 industrial companies. The project was initiated because of the growth in population and in motorization, especially in developing countries.

Mr. Dale identified several achievements of the report but noted that consensus was not achieved on every point. The members did agree that action is required on sustainable mobility challenges. The report presents a definition of sustainability agreed on by the participants and an assessment that concludes that current trends are not sustainable. The report also serves as a wake-up call for industry and identifies focus points for government and industry in moving toward sustainability.

The report, which focuses on roads and motorized vehicle transport, adopted 12 indicators: access to mobility, user costs, travel time, reliability and comfort, safety, security, greenhouse gas emissions, impacts on the environment and public well-being, resource use, impacts on public revenues and expenditures, equity implications, and rate of return to private businesses. If present trends continue, some indicators, such as conventional emissions, safety, and affordability of goods mobility, look better. However, others, such as greenhouse gas emissions, congestion, and equity, look worse.

The report outlines seven goals to reverse the indicators that are looking worse:

- Reduce transport-related emissions to levels where they cannot be considered a serious public health concern anywhere in the world.
- Limit transport-related greenhouse gas emissions to sustainable levels.
- Significantly reduce the worldwide number of deaths and serious injuries from road crashes.
- Reduce transport-related noise.
- Mitigate transport-related congestion.
- Narrow the mobility "divides" that exist today between the average citizen of the world's poorest countries and the average citizen of the wealthier countries and between disadvantaged groups and the average citizen within most countries.
- Preserve and enhance mobility opportunities available to the general population.

Actions that companies can take are still under discussion, but to start they should continue with the extensive activities that are planned or under way, serve as catalysts to advance the understanding of sustainable transportation within companies, continue the debate internally, and encourage other industries to undertake similar studies.

Emil Frankel began with a brief update on the status of the federal transportation funding reauthorization. He noted that the issue of sustainability is not new to the Transportation Research Board and cited precursors to this conference. Continued efforts with regard to sus-

tainability are necessary because it is difficult to get a democratic society to act unless there is an impending crisis, and in the case of sustainability, once there is a crisis it will be too late.

The U.S. Department of Transportation struggles to provide safe, efficient, and effective mobility while dealing with the intertwined issues of sprawl and urban growth patterns. The current pattern of development was enabled by the automobile, technology, and personal choice. While the sustainability of this development pattern is often questioned, it is difficult to alter. In a democratic society it is nearly impossible to tell people that low-density suburban development and dependence on the automobile must change.

As policies are made, trade-offs and the impacts on all aspects of sustainability must be measured. The role of the U.S. Department of Transportation is to establish a framework for decision making including financing, planning requirements and processes, and market and regulatory processes to achieve public policy goals. Mr. Frankel emphasized the importance of discussions and broader debate and dialogue on how to invest in transportation infrastructure. Capacity expansion is needed in all modes to handle goods coming into ports as well as for mobility of people and freight.

Automobiles and trucks are the predominant modes of transportation and are here to stay. It is important to reduce their impacts on communities. The need to reduce these impacts places a burden on the transportation planning process. Metropolitan planning organizations are key players in the planning process: they balance trade-offs, make decisions, and prioritize investments. However, they lack geographic reach and resources. Significant achievements have been made in transportation planning with regard to integrating the National Environmental Policy Act and air quality conformity, but more improvements are needed. Environmental stewardship must be incorporated into all aspects of transportation planning. Planning must focus more on systems operations management, strive for intermodality, and link to land use decisions.

Mr. Frankel emphasized the importance of technology to sustainable mobility. More efficient automobiles, new propulsion systems, greater use of hybrids, and other technological advances are moving toward sustainability objectives. The U.S. Department of Transportation, the Department of Energy, and the Environmental Protection Agency all have roles to play in driving technological change.

The U.S. Department of Transportation is committed to and recognizes the significance of sustainable mobility and sees transportation planning as an important tool in addressing it. Transportation planning in combination with the use of priorities and indicators can assist in moving toward sustainability.

Poster Session

On the first day of the conference, seven participants presented posters on a range of topics relevant to integrating sustainability into the transportation planning process:

- *Transportation and Land Use Planning*, Nat Bottigheimer, Maryland Department of Transportation.
- *States, Freight, and Technical Tools: Review of Progress and New Projects at the Center for Clean Air Policy*, Greg Dierkers, Center for Clean Air Policy.
- *Sustainable Transportation Planning in the Portland Region*, Jennifer Dill, Portland State University.
- *Travel Matters: Mitigating Climate Change with Sustainable Surface Transportation*, Sharon Feigon, Center for Neighborhood Technology.
- *Sustainable Transportation Study in China*, Yulin Jiang, China Academy of Transport Science, Ministry of Communication.
- *What Makes a Transportation Plan Sustainable?* David Kriger, iTRANS Consulting, Inc.
- *Education and Sustainable Transportation,* Joseph Szyliowicz, University of Denver.

Conference Closing

David L. Greene, *Oak Ridge National Laboratory*

The conference chair, **David Greene**, began his closing remarks by summarizing the concept of sustainability as "meeting the needs of the current generation without compromising the needs of future generations." While this may seem like a basic concept, achieving sustainability is not a simple task. That the participants of the conference have struggled with identifying solutions to sustainability challenges is not surprising, given the uncertainty and multiple dimensions of the objective.

Despite the uncertainties, sustainability is compelling and is seen by broad groups as important and right. It is no longer only environmentalists who fight for the cause, as demonstrated by the remarks of representatives from the automotive industry, the Federal Highway Administration, and state departments of transportation at this conference. Many recognize that the sustainability crisis is right now and that there is an urgent need to make future generations part of the transportation decision-making process.

Dr. Greene thanked the conference participants for their hard work and for bringing forth their ideas and insights. The conference, through its report, has an opportunity to define the vision of a sustainable transportation system clearly and to identify next steps to integrate sustainability into transportation planning.

RESOURCE PAPERS

RESOURCE PAPER

Sustainable Transport
Definitions and Responses

William R. Black, *Indiana University*

This paper was prepared in response to the two questions noted in the conference program: What are the ranges of definitions of sustainable transportation in practice today? How do these definitions affect how transportation sustainability is addressed? The first requires an inventory approach to what is out there and what has been in fashion in the way of definitions over the past 10 to 15 years. Those looking for consensus will probably not find it here. The second question is a little more difficult, if not impossible, to answer in a precise way. There are two reasons. First, we can't really say how something is being addressed if we have no general agreement on what it is. Second, the major purpose of this conference is to try to get sustainability types of notions into the transport planning process, and this suggests that at least up to now it has not been addressed. Therefore, before we examine the second question we will at least suggest some of the components of a sustainable transport system on the basis of the definitions and other literature. Given this background, we can then suggest some actions that have been taken toward making the transport system sustainable with regard to these components.

Sustainable Transport: Meanings and Responses

It is reasonable to begin the discussion with some common types of definitions of sustainability and sustainable transport that one might find in a dictionary. This will only yield words such as durable or capable of being maintained and in reality get us nowhere. More than that, it angers some researchers who see these words as having far deeper meanings than I would intend. As a result, moving directly to the definitions may be the most prudent course to take.

One of the first uses of the phrase "sustainability" in something approaching the current context was in the so-called Brundtland report of 1987 (United Nations World Commission on Environment and Development 1987). That report discussed what was referred to as sustainable development, which was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition can be extended without major changes to sustainable transport, which may be defined as transport "that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs" (Black 1996). This is easy to understand on the surface, but soon we would have to face the fact that the *needs* are not well specified, and if we could resolve that, we must then stop and imagine how many *future generations* we are talking about.

Another way of expressing these ideas would be to state that sustainable transport represents transport and mobility with nondeclining capital, where capital would include human, monetary, and natural capital (Pearce et al. 1989; Daly 1992). Followed to its logical end, this would imply that natural resources could not be used in the system (sometimes referred to as strong sustainability) unless they were used to develop additional natural capital (sometimes referred to as weak sustainability).

Daly (1992) does not define sustainable transport but specifies parameters for any sector being sustainable. Within this context transport is sustainable if it satisfies three conditions: (*a*) the rate at which it uses renewable resources does not exceed their rates of regeneration, (*b*) the rate at which it uses nonrenewable resources does not exceed the rate at which sustainable renewable substitutes can be developed, and (*c*) its rate of pollution emissions does not exceed the assimilative capacity of the environment.

If we apply Daly's conditions to the transport systems of the 1700s and 1800s, which are often viewed as sustainable, we would find that these systems were on the verge of becoming nonsustainable. The major long-distance transport mode of the 1700s was sailing ships. Although they used renewable wind energy, they were becoming nonsustainable because they were depleting lumber stocks used in their construction and repair (Albion 1965). The typical transport mode of urban areas in the 1800s was the horse–wagon–buggy–carriage system. That system resulted in tens of thousands of horses polluting streams, wells, and streets of these urban areas and obviously exceeded the assimilative capacity of these environments (Lay 1992).

It should be apparent that today's transport systems fail to measure up to Daly's second and third criteria: today's systems are consuming fossil fuels (specifically petroleum-based gasoline) at rates in excess of the rate at which an alternative can be produced.

Schipper (1996) states that sustainable transport is transportation where the beneficiaries pay their full social costs, including those that would be paid by future generations. He further notes that changes in travel are associated with a number of prominent externalities, including accidents, air pollution, congestion, noise, damage to species habitat, increases in carbon dioxide production, and the importation of oil. It is these externalities, and not transportation or travel per se, that threaten the sustainability of the system, according to Schipper.

Gordon (1995) is less willing to be drawn into a debate over definitions of sustainable transport and states instead that underlying these ideas of sustainable transport are three different visions. The first centers on changing people and the way they live, the second on changing technology, and the third on changing prices (Gordon 1995). In effect, she is proposing, in rather broad terms, what actions are necessary to make the transport system sustainable.

Probably in an attempt to be more comprehensive, the Centre for Sustainable Transportation (1998) in Canada states that a sustainable transportation system is one that (*a*) allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations; (*b*) is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; and (*c*) limits emissions and waste within the planet's ability to absorb them, minimizes consumption of nonrenewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise.

Europeans tend to refer to this notion of sustainable transport as sustainable mobility. Some U.S. groups also prefer the use of this term. The *Mobility 2001* report defines sustainable mobility as "the ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future" (Massachusetts Institute of Technology and Charles River Associates 2001).

Transport Canada skirted the definition of a sustainable transport system and sought instead to define "a more sustainable transportation system" as "one which provides *affordable access* to freight and passenger service and does so in an *environmentally sound* and *equitable* manner" (Bell et al. 1997).

In later reports Transport Canada has set out to provide a framework that addresses the social, economic, and environmental elements of a sustainable transportation system. More specifically, it seeks the highest practical standards of safety and security, economic efficiency, and respect for the environment so that transport's "impact on the environment and on the health of Canadians is acceptable to current and future generations" (Transport Canada 2003).

Greene and Wegener (1997) and Pearce and Warford (1993) define sustainability in economic terms. In this context sustainability is holding the sum of the capital stocks of manufactured, human, and environmental assets at least constant to ensure that future generations have the same capability to develop as current generations. Greene (personal communication, June 24, 2004) has further stated that "sustainability is a constraint on the economic system which insists that we do not decrease opportunities for well-being available to future generations below the level we have today. This is an ethical doctrine, and therefore inherently subjective not objective. It defines a new market failure, because future generations cannot participate in the existing marketplace to express their preferences."

Favoring an objective conceptualization of sustainability, Black (2002) has asked the question, exactly what is it that makes the current transport system not sustainable? He has concluded that the lack of sustainability is due to global atmospheric problems, excessive use of nonrenewable resources by the transport system, excessive fatalities and injuries, local air pollution problems, and system congestion. To operationalize this approach, he made use of indicators in order to identify whether an area's transport system was sustainable.

There have been several other proposals for the identification of indicators of sustainable transport, often in the absence of a clear definition of what sustainable transport is. One of the leading efforts in this regard was outlined for the National Science and Technology Council Transportation R&D Committee by Heanue (1997). At the time the indicators under consideration included the following:

1. Market penetration of alternatives to petroleum-based fuels;
2. Transport sector emissions of greenhouse gases;
3. Water quality, number of species endangered, soil protection, and so forth;
4. Acres of revitalized urban area and reclaimed brownfield sites;
5. Trip making and miles traveled (by mode);
6. Reliance on single-occupant vehicles;
7. Access to jobs and services for the transport-disadvantaged; and
8. Population in areas that attain national atmospheric air quality standards.

The list includes several variables relating to behavioral aspects of travel and transport, perhaps with the idea that voluntary action by drivers may be critical in making the transport system more sustainable. It is not clear how far this effort went, but it involved several agencies of the federal government at the time.

Litman (n.d.) proposed a different set of sustainable transport indicators that is based more on personal or household travel characteristics. The following are included in his list of indicators:

1. Average portion of household expenditures devoted to transport;
2. Average amount of residents' time devoted to nonrecreational travel;
3. Per capita automobile mileage;
4. Ability of nondrivers to reach employment centers or services;
5. Per capita land area paved for roads and parking;
6. Quality of pedestrian and bicycle facilities;
7. Quality of public transit (frequency, speed, safety, and so forth);
8. Special transit services and fares relative to low income;
9. Transit coverage, residents within 0.5 kilometer;
10. Motor vehicle accident fatalities;
11. Per capita transport energy consumption;
12. Medical costs attributable to transport;
13. Publicly financed transport costs; and
14. Residents' role in transport and land use decisions.

Broadly speaking, these are representative of the approaches that have been taken to define or indicate what sustainable transport is. Some of the definitions are narrow, some are broad, and some seek to use indicators of the phenomenon, probably with the view of moving toward measurement at some point.

Nonsustainable Components of Transport

It may make sense to identify some of the phenomena that are generally accepted as leading the transport system away from sustainability. We have done this to an extent, but for those unfamiliar with this area further discussion may be useful.

Diminishing Petroleum Reserves

It is generally recognized that in the 100 or so years of motor vehicles using gasoline as a fuel, the world has consumed approximately 1 trillion barrels of petroleum for this and other purposes—all of this at a time when only a small proportion of the population of that world had access to such vehicles or other uses for petroleum energy. The major question at this point is, what is the future demand for this fuel and will the Earth be able to supply it? Given that the developing world is expected to increase its demand for energy in transport and other sectors, which has already begun, global demand will increase significantly.

What can be said of supplies? The optimist would say that there are about 2 trillion barrels of recoverable conventional petroleum reserves out there. In general, production keeps pace with demand, but if the latter increases significantly, it is likely that additional production will have to take place. At present consumption exceeds new discoveries by more than a 3:1 ratio. Some scholars believe we have found all of the major fields in the world. The discovery of more major fields (perhaps in the South China Sea) will probably only enable the world to fight a delaying action (Deffeyes 2001). Others would say that the conventional sources will not last beyond 2020 and that there is significantly more petroleum out there, but it is found in unconventional sources (Greene et al. 2003). Such sources would include shale oil, oil sands, and tar sands. Estimates are that shale oil is substantially more expensive to produce and deliver, while the others have costs that are comparable with those of conventional sources. Depending on what the actual costs are, we will see the slower or faster development of alternative fuels. In the final analysis our current transport systems are nonsustainable because at least at present they use a fuel that is finite and nonrenewable. This is true whether we are talking about conventional or unconventional sources of petroleum.

Global Atmospheric Impacts

Some researchers believe that humans are placing emissions into the atmosphere that will eventually have impacts on the global climate. Others believe these impacts have already begun with increasing global temperatures and a rise in sea level. The emissions, sometimes called greenhouse gases, may lead to a forcing or an enhancement of the greenhouse effect. This is the effect that under normal conditions enables the planet to sustain enough heat to make it amenable to life. More specifically, the burning of fossil fuels has released substantial amounts of carbon dioxide, a greenhouse gas, into the atmosphere, and this will lead to a forcing or an increase in the global average temperature. As of 2001 carbon dioxide concentrations have increased 31 percent over levels in 1750. These levels are now higher than they have been in the past 420,000 years (Intergovernmental Panel on Climate Change 2001). Transportation and the use of petroleum-based fuels are responsible for just over 20 percent of these emissions as of 2003. This is nonsustainable according to the 2004 *World Energy Outlook* of the International Energy Agency.

One might reasonably ask whether the warming will create major problems or will be only a minor inconvenience. We really don't know the answer, but the consensus is that the negative impacts of only a minor change in temperature could be substantial. There is a tendency among many sectors to want to ignore the impacts on the planet. This may be possible for some sectors, but it is not so easy for transport. The flooding of transit tunnels due to a rise in sea level, the failure of airplanes to take off due to high temperatures, the buckling of highways and railroad track due to heat, the flooding of coastal highways and railways, and the submersion of dock facilities are not problems that can be dismissed easily. Even more important is the potential shift in agricultural production to new areas with moderate climates and away from areas that are too hot or too dry, which would result in the need to relocate transport infrastructure in such areas (Black 1990).

Local Air Quality Impacts

The contribution of motor vehicle emissions to the problem of poor air quality is significant. This must also be seen as something that makes current transport systems nonsustainable. As of 2000, according to the Bureau of Transport Statistics, mobile sources accounted for 7 percent of sulfur dioxide emissions, 43 percent of nitrogen oxide emissions, 51 percent of carbon monoxide emissions, approximately 9 percent of particulates [2 percent of PM10 (particles up to 10 micrometers in diameter) and 31 percent of PM2.5], and 33 percent of volatile organic compounds. A substantial portion of the production of urban ozone also has its origin in mobile sources. The various pollutants must be viewed as contributors to nonsustainability, and they are viewed as such in Europe and by the Organisation for Economic Co-operation and Development (1998). They have not always been viewed as part of the sustainability problem in the United States, but this may be because these problems were and are being addressed. This attitude seems to have changed in recent years.

The negative health impacts of these emissions, primarily on the human respiratory system, must be viewed as a significant problem that cannot be allowed to continue. The United States has made substantial progress in reducing the significance of these emissions, and some believe they will cease to be a significant problem in the foreseeable future. Nevertheless, at this time these emissions are one of the factors making transport systems nonsustainable.

Fatalities and Injuries

It should be an accepted premise that a transport system that kills off its users is not sustainable. However, many policy makers do not want to include fatalities and injuries in the calculus of nonsustainability factors. Indications are that the world's motor vehicle fleet is responsible for nearly 1 million fatalities each year and probably 70 million or more injuries (World Health Organization 2001 as cited by Evans 2003). Global forecasts of fatalities for the next 10 years are almost beyond comprehension.

Fatalities per vehicle mile are dropping in the United States, but that is probably due primarily to increases in vehicle miles driven. Until recently total fatalities were also dropping, but the latter appear to be increasing now or at least leveling off. We are no longer sure what is happening with injuries.

Congestion

Policy makers in general do not view congestion as a major barrier to transport sustainability. Even this conference is giving it rather short shrift. The reason is not at all clear, although it may be attributable to the indirect nature of the impacts generated. Congestion decreases the speed of vehicles and results in lower fuel efficiency. It increases emissions that are detrimental to both the global and the local environments. It increases motor vehicle incidents, while it decreases fatalities. Perhaps it was viewed as a manifestation of all the other

criteria leading to nonsustainability and its inclusion seen as redundant.

Several years ago at a Transportation Research Board annual meeting the following question was asked: If we adopted a renewable transport fuel with zero harmful emissions, would we have a sustainable transport system? The question was never answered, but it is one that must be asked again. Clearly, if hydrogen was the fuel, our concerns about the depletion of fuel stocks would be removed, as would the problems of global atmospheric impacts and local air quality. Fatalities would also be reduced, since motor vehicle accident fires would be eliminated in the case of a hydrogen fuel. However, we would still have the problem of congestion in urban corridors and increasingly on major Interstate highways, and this, and eventually gridlock, must certainly be viewed as contributing to nonsustainability. So the answer to the question is that even a wonder fuel would not make the transport system sustainable. We would still have congestion, which threatens only to get worse in the coming decades.

Noise

One major difference between sustainable transport in the United States and sustainable mobility in Europe is the latter's concern with noise. There is a wealth of literature suggesting that loud noise and continuous noise can be harmful to human health. The harm may be psychological and result in nervousness and behavioral disorders, or it may be physiological and result in impacts as significant as heart disease from the excess production of adrenaline. Many European nations are attempting to lessen the level of noise, particularly in urban areas. Of course, the same reactions are inherent in the transport systems of North America, and researchers are trying to minimize them. However, the problem and reactions to it are rarely viewed as part of the criteria making transport nonsustainable here. The density of cities and urban activities in Europe undoubtedly makes this factor more significant.

Biological Impacts

Much attention has been given to the need to protect biological resources from the damage created by transport activities (Transportation Research Board 1997). Animals killed along highways [estimated to be between 4 million and 6 million annually (Black 2003)]; rivers and streams polluted and marine animals killed by runoff from highways, runways, and the like; and plants destroyed by emissions are all representative of these biological impacts.

Perhaps the most devastating transport incidents in terms of biological resources are the tankers that break up and spew thousands of gallons of oil into the ocean or waterway they are traversing. Marine animals and waterfowl are often the most visible victims of such incidents on the evening television news. At the same time we must realize that these are local impacts—severe, but local. We have never lost a species because of an oil spill. It is far more likely that we will eliminate a species of marine life through overfishing than through operations in the transport sector.

Although we are not at risk of losing biological species because of the nonsustainability of transport, there is no doubt that transport impacts in this area are significant, as evinced by Forman's *Road Ecology* (2003) and the 1997 report *Toward a Sustainable Future* (Transportation Research Board 1997). The latter report focused on climate change and ecosystem impacts, results of one of the narrower definitions of sustainable transport.

Equity

Other researchers have looked at the question of what makes the transport system nonsustainable, and in so doing they have focused on the equity of the earlier definitions (Litman 1999; Feitelson 2002). Some of these definitions dealt with the notion that operations on the current transport system should not jeopardize the possibility of future generations satisfying their transport needs. This is not meant to imply that future generations should have the same type of transport system that we have today, although some have read it that way. It simply means that if we are going to continue with a system that is based on finite petroleum reserves, then we should have another fuel available for those future generations. This is what is meant by transgenerational equity.

It also is believed by some that if the transgenerational argument is acceptable, then the current transport system should be equitable. An equitable transport system would be one that is fair, impartial, and just. Contrary to popular belief, it has nothing to do with transport facilities being equally accessible or available for all potential users. To think so is to confuse income policy with transport policy. It is clear that these questions have not been dealt with enough in the transport literature, and perhaps we will get better insight into these aspects of sustainable transport in the near future.

Impacts of the Definitions on How Transport Sustainability Is Addressed

In certain ways the definition of sustainable transport is extremely important. This is particularly so if multina-

tional regions, nations, states, and urban areas allow the definition selected to guide all of their actions in the realm of sustainability. It is unlikely that many areas would do this, but there is some belief that many of the definitions involve controlling problems that are a function of the amount of travel that takes place. Some local areas might see the best approach to sustainable transport as one that involves decreasing the level of vehicle miles traveled. The general problem is more complex than a single-variable approach can handle.

A more fundamental question would be, what is being done to address the problems preventing the current system from being sustainable, whether one places the problems in that context or not? In this regard there is reason for some optimism.

Diminishing Petroleum Reserves

Diminishing petroleum reserves are being addressed in several ways. These are not necessarily planning based, and I will return to that later. Since the 1970s we have had corporate average fuel economy standards and the gas guzzler tax, both intended to encourage motor vehicle manufacturers to produce cars that use less fuel per unit of distance traveled. Recently the average miles per gallon has begun to drop, which may be attributed to the increasing number of sport utility vehicles in the vehicle fleet. Nevertheless, the fuel savings since the mid-1980s are notable.

Another major improvement in this area is the development of hybrid (gasoline–electric) vehicles such as the Honda Insight and the Toyota Prius. They significantly increase fuel economy, although not by as much as some may have hoped.

Development of alternative fuels is perhaps what most people believe will be necessary in response to diminishing petroleum reserves. On this front the news is not quite so good. Hydrogen is the promising alternative to petroleum-based fuels, but it is still far too expensive to produce at a price that will be competitive with gasoline. Ethanol is also not a major alternative now, and it is unlikely to have a major role in the future. Aside from subsidies needed to make it competitive, it uses land that might better be used for food production.

The motor vehicle industry has introduced different intelligent transportation system technologies into vehicles that should prevent drivers from getting lost. Most notable here is the combination of geographic information systems and the Global Positioning System, which decreases wasted travel.

Planners are not able to do a great deal in this area beyond the obvious attempts to allow certain commercial facilities (e.g., grocery stores) to be more ubiquitous, which would result in less driving and fuel use. This may require zoning changes in many communities. To the extent that planners have input into the process, they can encourage the development and improvement of public transit facilities that promise to remove some drivers from streets and highways. Programs that encourage carpooling would also be useful in some cities.

Global Atmospheric Impacts

The principal global atmospheric impacts from the transport sector are emissions of carbon dioxide and the escape of chlorofluorocarbons (CFCs). The former are a significant portion of the carbon dioxide emissions from all sectors. The Kyoto protocol was intended to set limits on these emissions for most of the developed nations of the world, but the United States refused to sign on to the protocol. More recently, some European nations have begun to sound as though they will back away from it.

Carbon dioxide and some trace gases are collectively referred to as greenhouse gases. It is generally believed by the scientific community that emissions of these gases will cause a warming of the planet and that this in turn will lead to melting of some middle-latitude glaciers and upper-latitude ice cover, and that this melting along with thermal expansion of the oceans will result in a rise in sea level. The ramifications of these changes run the gamut from losses of viable crop production areas to changes in the currents of oceans.

Planners and local areas have not done a great deal about this problem as such. If they advocate some of the methods of decreasing fuel use noted above, they will be able to decrease carbon dioxide emissions, which are currently running at about 20 pounds of carbon dioxide per gallon of gasoline burned.

California has enacted legislation that will require automobile manufacturers to produce motor vehicles with significantly lower carbon dioxide emissions by 2010. Legal challenges to the statute are likely, but if it can withstand them several eastern states are likely to adopt similar laws.

The major concern with regard to CFCs is that they were creating holes in the ozone layer surrounding the planet. The holes increased the amount of ultraviolet radiation reaching the surface, which would lead to problems ranging from disturbances to the ocean food chain to an increase in human skin cancers and eye ailments.

CFC emissions have plummeted since the end of 1995, when the Montreal protocol brought a swift end to the production of this coolant–solvent. Some CFCs still escape into the atmosphere from older automobiles, but this is probably not significant as we approach the

ninth anniversary of the withdrawal of CFCs from the marketplace.

It would be misleading to think that the problems of the ozone layer have been solved. Emissions of CFCs set in place a chain reaction that continues today. We cannot be certain when it will cease, although a couple of decades has been suggested.

Local Air Quality Impacts

Significant strides have been made in this area because of the fuel emission standards of the U.S. Environmental Protection Agency. Laws requiring reductions in emission levels have also been enacted. They have been successful in reducing the levels of nitrogen oxides, sulfur oxides, volatile organic compounds, carbon monoxide, and particulates. Levels of CFCs (found in automobile air conditioners) and lead in gasoline have been reduced significantly.

Acid deposition is a product of nitrogen oxide and sulfur oxide emissions. The transport sector's contribution is not significant. Although convection does allow some tailpipe emissions to become contributors to what becomes nitric and sulfuric acid "rain" and this in turn leads to biological and economic impacts, this is one problem that seems to be improving.

Fatalities and Injuries

Significant improvements in the fatalities and injuries area have been made over the past 40 years. Fatalities were in the 50,000-plus range during the 1960s, and we have seen improvements during the past several years that place this number nearer 40,000.

Between 1999 and 2004, the fatality rate per 100 million vehicle miles traveled decreased from 1.50 to 1.46 (www.dot.gov/affairs/dot10605.htm). In March 2004 the United States set a national target of a 33 percent reduction in fatalities in the next 4 years. The reduction is expected to occur through increases in seat belt use, stronger enforcement of drunk driving laws, and hours of service regulations for motor carriers. The target is achievable. Other countries have set more ambitious targets (e.g., Sweden has set a target of zero fatalities), but the action taken by the United States is a significant improvement over prior goals that have been set. Most other countries have not established any goals in this area.

Congestion

Local planners and engineers have a significant influence on the problem of congestion. The placement of demand-responsive signals, lane designations, highway expansion, parking control, and a host of other factors can be and are controlled at the local scale by these individuals. They may also be influential in getting local establishments to allow more flexible arrival and departure times and therefore enabling a flattening of the a.m. and p.m. travel peaks. In addition, they are able to assist with the creation and maintenance of carpooling and similar operations.

Although congestion appears to have almost leveled off in the past few years, there is no reason to assume that this will continue. Therefore, it is likely that something more will have to be done. Interesting technologies are possible in this area (e.g., electronically connected convoys), but expense will probably prevent their appearance in the near term.

Noise

Transport noise exists in some communities in the United States. The problem is usually combated with the construction of sound-absorbing walls or similar structures. In parts of the world where the human landscape was well established before the arrival of motor vehicles, this is not as easy to do. Europe and parts of Asia have significant noise problems. Some experimental work is being done with sound-absorbing highway pavements, but it remains to be seen whether they will help in areas where the individual cars are relatively quiet but the total noise generated in a traffic stream is significant.

The problem is not as bad in North America as in Europe, partly because of the lower density of settlement, which enables highways to be placed at some distance from residential areas.

Low Mobility

Low mobility is as much a problem with sustainable transport as very high mobility. The provision of mobility is a key provision of several definitions of sustainable transport. Localities can increase mobility levels for their residents by making sure that transport facilities are available to all members of the community. They can do this through providing regular urban public transit, rural transit, or specialized transit (for the handicapped and others). Funding for such operations is often difficult to obtain, and a recent work (Ubbels et al. 2004) examines many alternative mechanisms in this area.

Biological Impacts

Transport facilities and operations can affect animal and plant life. In some cases the impacts involve destruc-

tion of local species or the loss of habitat. In other cases they involve expansion or contraction of species or the introduction of new species that may be harmful to existing organisms in an area. The latter usually occurs with plant introductions in urban and rural areas.

Highways have become the major cause of death among numerous animal species, and there is little reason to assume that this will end in the near future. While such impacts are often local and not detrimental to an entire species, it is nevertheless desirable that we try to prevent them. Some may argue that they cannot be prevented effectively, but numerous local projects involving tunneling under highways to provide a safe route for animal movements would counter this argument.

Equity

What could be and is being done to foster an equitable transport system now and in the future is not as easy to identify. It should be apparent that anything improving the situation with regard to the aforementioned definitions will contribute to transgenerational equity. With regard to the contemporary situation, it is not as clear what can be done, although to accept the transgenerational equity argument one must assume that it applies to the current scene as well.

Solutions to the various problems noted here would probably move toward a more equitable system, but some might argue this point. Their argument would probably go to the very nature of what is meant by an equitable transport system.

Final Clarification and Comment

The careful reader will recognize that all of the proposed attributes of a sustainable transport system have not been reviewed here. The primary reason is the host of definitions offered. For example, the *Mobility 2001* definition includes the ability to communicate, and Transport Canada's 2003 definition includes the "highest possible standards for security." Both may be desirable, but they are not necessarily components of a sustainable transport system.

If we want to strive for a sustainable transport system, we cannot weigh it down with every possible desirable attribute. This does not mean that these various other items cannot be pursued under the umbrella of sustainability, but let's not set the bar so high that in time participants simply throw up their arms and walk away. I am reminded of President Kennedy's 1962 transportation address to Congress, wherein he proposed a program for urban mass transit to stave off what appeared to be the rapidly approaching end of urban transit in the United States. The program put in place would have accomplished this, but soon transit systems were proposed to alleviate congestion, solve air quality problems, provide access for disadvantaged groups, and serve areas outside the original urban area. So many requirements were placed on urban transit that it could hardly satisfy them, and many view those investments today as largely unsuccessful. These systems are still in place, but I would not credit the goals and objectives of their creation for this. My concern is that we will try to do so much with our transport system under the rubric of sustainability that we will make the concept unworkable, to the detriment of current and future generations.

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What Are the Challenges to Creating Sustainable Transportation?

How Can Transportation Systems Become More Sustainable?

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"Sustainability" has become one of the watchwords governing policy deliberations and debates about transportation. The intensity with which sustainable transportation will be debated is likely to increase for decades to come. Like so many other words that have entered our vocabulary, such as "efficiency" and "equity," the concept is powerful and evokes strong reactions even as it is difficult to define and measure. William Black's paper has given us an intellectually rich overview of the concept of sustainability and the challenges that the concept poses, and other speakers have given us benchmarks that help us gauge the depth and breadth of the sustainability challenge. My goal is to provide a bridge between the morning overview and the breakout sessions that will follow this talk. More specifically, I will assess how transportation planners, policy makers, and public officials can take actions that will move us along a path toward sustainability. Because of the complexity of transportation as a human activity and as a physical network, we need to talk about actions that can be taken in the public sector, by private companies, and by individual citizens and households. Despite the importance of sustainability internationally, I will focus on sustainability in the United States to simplify the discussion and in recognition of our personal roles and organizations. I will draw on some insights from experience overseas.

On balance, the ability to travel and to ship goods at low cost over long distances, as provided through a complex of transportation systems and networks, has enhanced humankind's economic, social, and personal well-being. It has been a major factor in increasing access to health care, education, employment, and recreation, and improved access to a wider range of consumer goods has dramatically improved standards of living all over the globe. However, we are genuinely concerned about sustainability because of the growing disparities between those who have achieved these benefits and those who have not yet but certainly hope to in the future. The differences are especially noticeable because they exist at the same time that many are becoming aware that the worldwide stock of energy resources providing for mobility is being depleted at a rapid rate. We wish to reduce reliance on those limited resources while expecting increased mobility for a large proportion of the world's population. At exactly the same time that concern is growing with respect to the distributional aspects of mobility and the long-term depletion of energy resources, the atmospheric concentration of greenhouse gases (GHGs) is growing ominously, and scientific evidence has persuaded most of us that this is causally related to global energy consumption. Also, the negative byproducts of mobility in the form of air and water pollution, contamination of land, and the accumulation solid wastes are causing many to worry that the benefits of mobility may be less available to future generations, while the costs of today's mobility may be escalating dramatically.

To acknowledge these concerns in no way requires us to belittle the significance of the benefits of transport systems. The sustainability movement is a search for balance, and the attainment of balance between mobility and sustainability is an enormous challenge. While some will emphasize one side of the scale more than the

other, it is simply too easy to dismiss the importance of mobility in favor of sustainability and similarly too easy to deny the unsustainability of current global patterns of mobility and energy use. The real challenge lies in the recognition that both are critically important policy goals. The European notion of "sustainable mobility" suggests a search for balance, and that is why we are here. Our community is by no means unanimous in its perceptions of either the benefits of mobility or the costs of a mobility-dependent society or even about the definition of sustainability, but sustainability is here to stay as a subject of public debate and policy making. I hope we can make a contribution to clarifying that debate, but I hope even more strongly that we can influence the development of policy through our discussions at this conference.

Parallels with Earlier Environmental and Air Quality Movements, and a Prediction

Everything we do is in many ways the direct product of what came earlier. The current movement for sustainable transportation is not at all discontinuous with the history of transportation policy. We should, therefore, try to learn from that history. For example, in the late 1960s in the United States we were at the height of the national freeway building period that has now ended, and we were just starting to formulate a national program of capital investment in public transit. We tried at that time to find the right balance between mobility and environmental concerns, and the process was not at all easy.

Imagine for the moment that mobility had grown as much as it has since 1970 and that we had not as a nation adopted the National Environmental Policy Act of 1969 (NEPA). While we have certainly not eliminated the negative environmental impacts of transportation, our society is better off as a result of the passage of NEPA, even if we can think of many shortcomings in the NEPA process. Remember that NEPA was highly controversial, and many in the transportation community thought at the time that it would destroy our effort to create a more mobile society. In retrospect that fear was certainly not realized. As a result of NEPA, which has proved to be enormously robust by surviving thousands of legal and political challenges, we now incorporate environmental impacts of transportation more explicitly into the planning process at every stage. Transportation agencies employ environmental specialists and engage in community interaction much earlier in every planning, design, and engineering activity. NEPA helped to create a balance that in retrospect appears far more appropriate and less revolutionary than it did at the time. To a large number of people, the environmental impacts of many transportation projects are still intrusive and unacceptable; the law has been dramatic and its results have been extensive, but it has redirected and not prevented investments in improved mobility.

Imagine for the moment that mobility had grown as much as it has since the first air quality act amendments that affected automobile travel. In looking back on what has happened with respect to air quality over the past 30 or 40 years, most agree that we are much better off today than we would have been were automobiles producing as much pollution as they did in 1970. While we have certainly not eliminated urban air pollution and its health impacts, and our standards only recently have become more demanding because of improved understanding of the health effects of certain pollutants, few question that society is better off as a result of regulations that control air pollutant emissions and concentrations. The series of legislative actions taken with respect to air quality, like those associated with NEPA, were highly contentious. Many false starts were made, and onerous regulations were enacted and then amended. But, once again, contrary to the expectations of many, the results of NEPA and of air quality regulation have been enormous. They have redirected and not prevented investments that have improved mobility.

Imagine for the moment that it is now 2040 and that personal mobility and goods movement have grown as much as they were predicted to grow in both developed and developing countries. Looking back on what happened with respect to sustainability, I venture to say that we could not in 2040 imagine what the world would be like had the concept of sustainability not been acted on in the interim—for example, had levels of energy used per unit of transportation in 2004 prevailed up until this date. It will probably have proven impossible to provide the world with completely sustainable transportation, and new knowledge will have caused us to develop new demands and limits that we cannot conceive of in 2004. Nevertheless, the contentiousness of today's debates will have paled, and attention to improved sustainability will have redirected but not prevented investments in improved mobility.

Awareness of Sustainability Is Growing, but the United States Is Lagging Behind

Though sustainable mobility is becoming a more widely shared goal, we are still in the early stages of organizing societal action toward meeting that goal. It would be wrong to think that we have little or no interest in or commitment to sustainability. Actions are being taken despite strong differences of opinion and some confusion. However, society is complex, and that complexity is one of the most important sources of our apparent

inertia. Furthermore, sustainability remains a broad and vague concept, and that contributes to our inertia.

Within the European Union there is a strong imperative to achieve the 8 percent GHG reduction targets set by the Kyoto protocol, and some countries have embraced the goal to exceed the Kyoto targets by quite a margin. In contrast, of course, the United States has refused to sign the Kyoto accords. Transportation-based emissions in the United States (about one-third of all emissions of GHGs) are rising at about 3 percent per year, while emissions from residential and commercial sources are rising even more rapidly (Banister and Pucher 2003). Even if these trends cannot be reversed fully, their direction and speed must be changed, and I hope that we can proceed into the workshops unified in this commitment.

Despite the reluctance of the federal government to take responsibility for GHG reduction, there has been much activity in the United States in pursuit of sustainable mobility. A recent survey by staff members at the Volpe Transportation Center found that as of May 31, 2001, a surprisingly large number of states—25 states plus Puerto Rico—had initiated the process of developing statewide GHG reduction plans and that 19 had completed those plans. In addition, 134 cities and counties had, by that date, initiated voluntary GHG planning activities, which, at a minimum, include commitments to pass supportive resolutions, conduct baseline estimates, develop action plans, and monitor results (Lyons et al. 2003). After reviewing this national pattern, the authors studied a subsample of these programs in depth. The following were among the most interesting and useful conclusions with implications for our discussion:

- Local and regional agencies often act out of the realization that they stand to suffer damage themselves from global climate change unless trends are reversed. The recognition that they might themselves suffer from rising water levels, negative impacts on tourism, and damage to forests was often associated with interest in developing plans for GHG reduction.
- Local governments that adopted a formal approach, with goals, deadlines, inventories, and forecasts, tended to be more effective than those that were well meaning but less focused.
- Planning was more often undertaken where GHG reduction was seen by state leaders to contribute to other ongoing state plans and programs, such as economic development and smart growth. In other words, where there was a strong tradition of environmentally responsible planning and the perception of complementarity with other planning efforts, sustainability planning had a better chance of being adopted.
- Planning was far more often undertaken where one or more political champions took a leadership role. Virtually all the successful plans occurred in places where mayors, governors, legislators, or other leaders championed their development and saw them through to completion.
- Transportation agencies were rarely the initiators or the lead agencies in preparing such plans. More often the lead agencies had responsibilities for energy, environment, or land use. While transportation agencies were often not in the lead and often lagged behind other sectors, the most successful plans resulted from multiagency collaboration.

It would be a mistake to conclude that there is little or no corporate interest in a more sustainable future. Much work is taking place in the private sector. As one example, for the past 4 years under the sponsorship of the World Business Council for Sustainable Development, 12 leading international automotive and energy companies have worked together to consider how global mobility patterns might evolve through 2030 and beyond and have attempted to identify strategies to make transport more sustainable. Though we may remain skeptical about the motivations of these corporations, the seven goals identified by the study team are completely consistent with the view of sustainability enumerated by William Black in the opening paper for this conference:

- To reduce conventional emissions from transport so that they do not constitute a significant public health concern anywhere in the world,
- To reduce GHG emissions from transport to sustainable levels,
- To reduce significantly the number of transport-related deaths and injuries worldwide,
- To reduce transport-related noise,
- To mitigate traffic congestion,
- To narrow "mobility divides" that exist within all countries and between the richest and poorest countries, and
- To improve mobility opportunities for the general population in developed and developing societies.

The report *Mobility 2030* (World Business Council for Sustainable Development 2004), now in the final stages of preparation for release, addressed all of these goals, but at different levels of depth and specificity. It gave greatest emphasis to and its most specific recommendations address power train technology, fuels, and energy issues. This is certainly understandable given the companies that have been involved. Still, the fact that a study took place and that a comprehensive set of sustainability goals has been developed by the companies is itself an indication that sustainability can become a major factor in private-sector planning, research, and marketing.

Taming the Complexity of Sustainability: Setting Priorities

Societies do not do well with complexity, nor in all likelihood do workshop conferences like this one. We need to find a way of reducing our discussion to manageable components, just as we need to find ways of enacting policies through manageable steps and workable components. We need to acknowledge complex relationships among the elements while focusing on them one at a time. We only seem to be able to enact laws and regulations, to take actions, and to set priorities one bite at a time. Even if we limit our discussion to the United States, which is in itself an enormous oversimplification of what needs to be done, we will not be able to address simultaneously all the dimensions of sustainability discussed so far at this meeting. We certainly will not be able to do so at all levels of government and within the private corporate sector and at the household level. Yet eventually sustainable transportation will require responses on all those dimensions and from all those actors.

I propose that our workshop discussions consider priorities for the coming decade while acknowledging that priorities will certainly change over time. We should consider how the various actors might contribute to sustainability most productively over that period. I have tried to illustrate the nature of the complexity we are facing in Figure 1, which presents the two dimensions of sustainability that I just mentioned. I recognize, of course, that the figure is a gross oversimplification of anything that might happen in the real world, but I still think it might facilitate dialogue in a number of ways.

One way of using a matrix like this would be to assign priority weights to a particular intersection of actors and elements. For example, one of us might think that the depletion of energy reserves is extremely important and that it should fall to the national government to play a large role, so a high score might be placed in the box where the national government row intersects the energy reserves column. Similarly, one might think that traffic congestion is an important public policy problem but that it is not really important to global sustainability and is primarily a problem that should be addressed by local and regional governments. This might be reflected by a moderate score in the box formed by the intersection of the traffic congestion column and the local government row, while zeros are entered in some of the cells elsewhere in that column.

Another way in which a matrix could help us organize our thoughts would be to fill into each box a few actions or strategies that might be most effective if taken by a particular actor (row) with respect to a sustainability element (column). For example, we might think that pricing would be an appropriate strategy by which state governments (row) could address congestion (column), while we might think that traffic safety (column) might best be addressed at the national level (row) through regulation of vehicles.

I offer this suggestion as a way of grabbing hold of a monster while recognizing that the issue remains enormously complex and that the elements of the matrix are indeed highly interrelated.

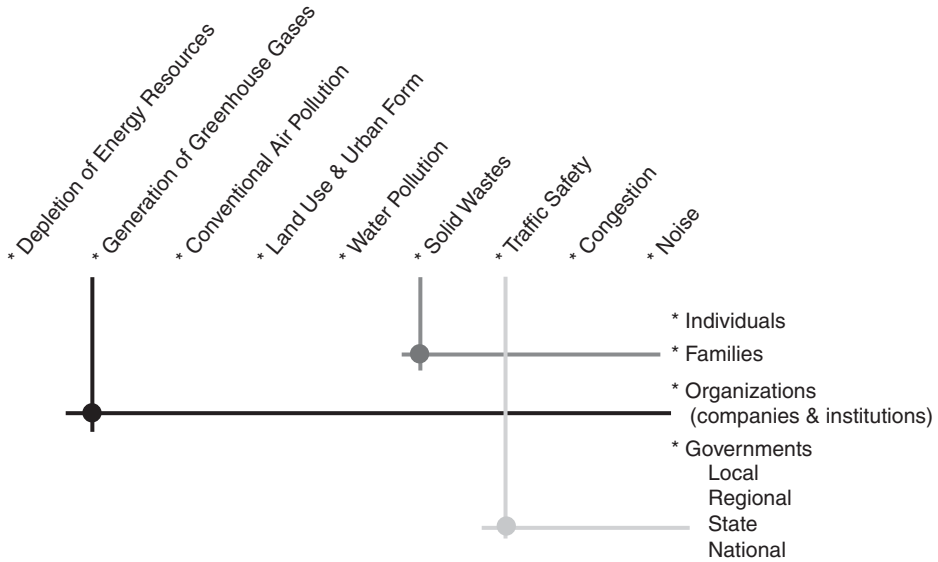

FIGURE 1 Complexity of sustainable transportation.

Key Questions Determining the Future of Sustainable Transportation

Indicators of Sustainability

A prerequisite to progress toward sustainable mobility is the development of a set of quantitative indicators by which to measure progress over time. American society already uses a wide variety of quantitative indicators of our well-being, and policy makers have become accustomed to responding to notable shifts in indicators over time. The best examples of indicators on which we rely in policy making undoubtedly are economic indicators. Such variables as unemployment rate, consumer price index, housing starts, and numerous others are used regularly to measure current conditions and changes in conditions over time. Interpretations of patterns among these indices differ, of course, and such differences are the basis of policy debates. Indeed, the differences in interpretation and the differences in policy recommendations suggested by the indicators are what make them most valuable. Indicators must be carefully chosen on the basis of their long-term policy relevance, interpretability, and implications for the collection of relevant and accurate information. If useful sustainability and mobility indicators can be developed, they might eventually be used to test and model the likely impacts of different policies on indicator values and thereby to interpret their impacts on sustainability. In the workshops we might agree that sustainability indicators are necessary to the development of policies that promote sustainable mobility and that we might then concentrate on the nature and content of appropriate indicators.

The matrix introduced earlier makes it clear that some dimensions of sustainability, like GHGs, are most relevant because of their effects at the global scale. Others, like noise, can really only be measured and controlled effectively at the local scale. It would be helpful for our workshops to recommend indicators that operate at different levels and to discuss the sources of data that might be used to operationalize them. In the short term, given the current state of evolution of transportation policy, the most important indicators of sustainability are those that could be operationalized at the state and national levels. Those indicators would deal with levels of mobility, energy and resource consumption in transportation, and the production of GHGs and other waste streams.

Technological Changes

Most observers of transportation planning and policy agree that most of the progress made in the past 40 years toward lessening the environmental damage done by transportation has resulted primarily from technological change. Dramatic reductions in tailpipe emissions per mile of driving have led to equally dramatic improvements in air quality in some of our most polluted metropolitan areas even as the number of trips and vehicle miles of travel have grown substantially. Fleet fuel economy has improved as well, though perhaps less dramatically, and improvement has been slowing in recent years. These technological changes, of course, are not independent of political decision making. They are the result of regulation, mostly by the federal government but in some cases also by states, particularly states like California, which have had severe environmental problems to address. Most believe that changes in vehicle technology and fuels have been more influential than changes induced by regional transportation planning or changes in individual and household behavior. It follows that government regulations affecting technology have been far more influential and effective than government planning requirements or initiatives to change travel or residential location behavior. Should we, as a group, conclude that past patterns are a good predictor of the future, and therefore that the most promising approach to sustainability is through technological change? Or should we conclude that the attainment of sustainability requires a dramatic escalation of change and that technology alone will be unable to move us onto a path toward a sustainable transportation system?

Some will attempt to set limits on the role of technological change in approaching sustainability on the basis of moral judgments and positions that are strongly held for ideological reasons. I believe that technology will play a major role in sustainability policy because we are able to identify changes in technology that will improve mobility and enhance the quality of life while reducing the footprint left by human activity on the natural environment. As long as this is the case, technology should and will play a central role in the pursuit of sustainability.

But there are limits to our ability to rely on technological change. We must note that some of the potential benefits of improved engine efficiency and better fuel economy have been lost because manufacturers have produced and consumers have opted to buy vehicles that have grown larger and that include many energy-consuming options. The benefits of improved technology have, to some extent, been converted into larger, faster, and more luxurious vehicles rather than into vehicles having more modest performance features and dramatically improved fuel efficiency. Many American manufacturers, instead of focusing on smaller cars that are dramatically more fuel efficient, are promoting their forthcoming entries into the market for hybrid vehicles as bigger and more luxurious cars that get the same fuel economy as smaller cars.

Regulation Versus Market Forces

One of the ongoing debates in American policy making is whether market forces are sufficient to bring about technological and behavioral changes needed to achieve environmentally responsible mobility and eventually to approach sustainability. Clearly, for example, as supplies of energy become more limited prices will shift, and this will induce changes in consumption patterns and technologies. Key questions concern whether market forces will be sufficient or whether they need to be coupled with federal and state regulations. In the past, the corporate average fuel economy regulations that were part of the Energy Policy and Conservation Act and the tailpipe emissions standards and National Ambient Air Quality Standards required by the Clean Air Act Amendments have been controversial because they have attempted to force technological change. The California Air Resources Board, for example, last month introduced draft regulations in compliance with the state's S.B. 1493 that would require a reduction in vehicle carbon dioxide emissions starting in 2009 and amounting to a 30 percent reduction in new vehicles by 2015. The *New York Times* (Hakim 2004) recently reported that New Jersey, Rhode Island, and Connecticut are considering the adoption of similar regulations.

The appropriateness of direct government regulation versus greater reliance on market forces is a topic that could lead to some lively discussions in the workshop sessions. The case for centralized regulation has been well made over and over again by environmental and political philosophers such as Garrett Hardin and Aldo Leopold, who have shown that regulation is needed wherever resources are owned or controlled in common on behalf of communities. While many government regulations have been highly imperfect and some can be shown to have induced inefficiencies and inequities, it seems inevitable that regulation will play a central role in our quest for sustainable mobility. The challenge before us is to devise regulations that complement other approaches to achieving sustainability and that minimize unintended negative consequences. A great deal of analysis is needed in support of a program of regulation that produces a substantial excess of benefits over costs.

Direct Regulation of Travel Behavior

In America, we have found it politically feasible to regulate vehicles and fuels, and these regulations have certainly in turn affected consumer behavior. However, we have shied away from measures that were seen to be regulating households and individuals more directly. Under the requirements of the Clean Air Act Amendments, government attempted to regulate commuter choices through the Employee Commute Options Program and, for example, attempted to "cash out" free parking. While these initiatives have often been technically successful at a limited scale in improving vehicle occupancies and shifting commuters in measurable numbers to public transit or carpools, corporate and political objections to such programs have caused them to be viewed widely as less than successful, and in most cases eventually they have been abandoned. Should we, as a group, conclude that the attainment of sustainable mobility in the future requires more vigorous and direct regulation of travel decisions at the household and individual level, or should we conclude that such an approach is likely to be politically unacceptable in the United States for some time to come? It is my expectation that for the foreseeable future it will prove more appropriate and more feasible for political reasons to regulate vehicles, fuels, and emissions than to regulate personal or household choice making.

Still, we need to learn to be more clever and subtle in our use of regulation to achieve intended social purposes. Jonathan Levine's research, for example, shows that more conservative Americans often assert that it is "market forces" and "personal preferences" that lead us to prefer low-density single-family homes in areas characterized by single land uses. He disagrees, pointing out that often market forces and household preferences actually would lead to higher densities and communities consisting to a far greater extent of mixed land uses except for the fact that they are excluded by zoning and subdivision regulations prohibiting those land uses and requiring the traditional American suburban land use patterns. Those regulations were in many cases put into place decades ago to keep residences away from heavy industries. Today they inhibit rather than enhance our ability to achieve more current versions of appropriate land use mixes that support sustainability. The lesson to be learned is that regulation must be sensitive to the need for a range of human choices. This may suggest that the most appropriate regulatory strategies are those enhancing our choices among alternatives by focusing on performance measures related to policy outcomes rather than those limiting our choices directly (Levine et al. 2005).

Pricing

The use of pricing to influence travel behavior is closely related to the direct regulation of behavior, since one of the most direct ways of regulating behavior is through the setting of prices. Many have advocated for decades that pricing transportation programs differently could be among the most promising ways of approaching sustainability. Empirical evidence, particularly from inter-

national experience, supports this expectation. Taxes on new vehicles in Europe and some Asian countries do result in lower vehicle ownership rates, even where income levels exceed those in the United States. While vehicle ownership rates are growing in most of those countries, they remain substantially lower than in the United States. Consistently higher taxes on vehicle fuels in many other countries continue to be associated with the purchase of smaller and more fuel-efficient vehicles than in the United States. And where vehicles and fuels are more expensive, higher proportions of trips are made on public transit and by bicycle and walking than are typical in the United States, even where incomes are comparable. Yet American policy makers have been reluctant to attempt to price the externalities of transportation systems directly or even indirectly, or to use taxes as policy instruments for changing transportation behavior. Should we, as a group, conclude that more vigorous pricing of transportation is necessary and appropriate to bring about sustainable transportation, or are we reluctant to promote that direction of change in American policy? I expect that pricing strategies are becoming more politically acceptable than they have been in the past, for three reasons that I have developed elsewhere. First, there is an increasing need for revenues in support of transportation programs as traditional reliance on the fuel tax produces reduced revenue in relation to perceived needs. Second, the increasingly widespread deployment of a variety of automated and computerized mechanisms by which to collect payments, such as FasTrack and E-ZPass, is making it physically easier to collect transportation system use-related charges in a variety of situations. Finally, growing familiarity with prices and collection mechanisms is reducing concerns on the part of the public that such approaches are improper or that they constitute violations of the privacy of the traveler (Wachs 2005).

Individual Education

There is an enormous variation in travel behavior within American society, and we may conclude that this variation results, at least in part, from widely different attitudes. A few, for reasons that vary from personal preference to deep moral commitment, have chosen to be carless. These individuals rely much more heavily than others on public transit, walking, and cycling. Others, who would not think of rejecting automobiles, own motorized vehicles but consciously choose fuel-efficient ones such as hybrid cars. Where such behavior does not unduly complicate their lives, they cycle, walk, or use public transit for trips. Still others own multiple fuel-inefficient vehicles and regard it as irrational, futile, or unnecessary to alter behavior through direct personal action when public policy does not demand or reward such behavior. This variation in attitudes, commitment, and behavior is in need of deeper study and analysis. Some believe that public education is the key to sustainability. Those holding this position cite precedents in other areas of American life for their belief that education can be enormously effective: the reduction of smoking, the rise in recycling, the reduction in drinking and driving, the adoption of "safe sex."

Some promote "social marketing" or education as a key to the eventual sustainability of our transportation system. They argue that Americans are bombarded with advertising that, for economic reasons, encourages them to purchase larger and less fuel-efficient vehicles and to use them for more and more reasons (McGovern 2004). In contrast, in parts of Europe and Australia and most recently in experiments in American cities such as Portland, Oregon (TravelSmart), willing households have had their travel choices "audited" by trained outsiders. Household members were helped to reorganize their weekly travel to take greater advantage of public transit, form trip chains that reduce the number of automobile cold starts, combine the trips of household members that were previously made independently of one another, and forgo some trips entirely. Some see this type of educational activity as promising for at least two reasons. The first is the direct shift in travel behavior toward sustainable mobility that they hope it will help to bring about. The second is the fact that education will, perhaps more gradually, contribute to changes in public policy by making more aggressive approaches to regulation more acceptable in the political arena than they are now. Others, of course, think that well-meaning experiments in consumer education are likely to result in little or no change in travel at the scale of our entire society. Still others consider such an approach to be completely misguided and doomed to fail, or worse, to interfere with individual freedom in a democratic society. Should we, as a group, conclude that widespread consumer education is one of the more promising approaches to the attainment of sustainable mobility, or should we conclude that this view is well meaning but likely to be ineffective in the foreseeable future?

Regional Planning

In the United States regional transportation planning has long emphasized the construction of transportation capacity. As environmental, especially air quality, and social and economic impacts have become increasingly important concerns in regional planning, our long-range transportation plans become more sophisticated, but they continue to emphasize capital investments in facilities.

In other parts of the world, however, the nature of regional transportation plans is changing more fundamentally. For example, regional long-range transportation plans have been formulated that emphasize a long-term commitment to sustainability as a first principle in Sydney and Melbourne, Australia, and in a large number of European cities. Such plans go far beyond proposing new capital investments in corridors where traffic volume is likely to grow. Some of these plans promote the redevelopment of older, formerly industrial or military sites into high-density, mixed-use commercial and residential centers in proximity to public transit facilities. Many have adopted approaches to regional planning intended to reduce the geographic expansion of metropolitan areas at their edges while promoting higher densities at their cores. Some have set specific, and in a few cases ambitious, goals with regard to changes in modal split or decreased rates of growth in automobile travel and in the generation of GHGs. Often these plans incorporate major capital investments in travel modes other than the automobile.

In a number of cases, emulated in a few notable planning activities in the United States, the effort to develop regional plans has identified threatened or sensitive natural areas and then worked toward plans that would accommodate forecast growth while protecting those environments. In other cases, planning models were used, as they have rarely been in the United States, to "backcast" rather than to forecast. That is, certain environmental and travel goals were developed for the target year of the plan, and the models were used to test alternative policies and consequently to select policies that would lead to the desired outcomes (Wachs 2000).

Should we, as a group, conclude that regional planning is of potentially great value in achieving sustainability and recommend that the regional planning process be substantially overhauled in support of sustainability? The answer is not at all obvious. In the past, planners and policy makers have urged that regional plans pay much more attention to transportation systems management, travel demand management, maintenance and renewal of the existing capital plant, and the systematic inclusion of telecommunications innovations through a transition to intelligent transportation systems. Despite such urgings and many revisions to planning regulations included in the national highway program, progress in reforming the regional transportation planning process has been limited. We appear to be unable to achieve the dramatic institutional changes that would be needed to make regional planning more capable of addressing sustainability. Some of us may argue that a number of factors—the inertia in our existing planning apparatus, the inevitability of some of our population and travel trends, and a reluctance to embrace aggressive regulation of the use of land and of travel choices—make it far less cost-effective in the near term to embrace regional planning as a sustainability strategy than to focus on technological change.

Conclusion

In this paper I have offered several questions that I hope can help structure the discussion that is to follow in our workshops. The questions are summarized as follows:

- Can progress toward sustainability in transportation be achieved in the United States primarily through technological changes in vehicles, power trains, and fuels? Is it cost-effective to rely primarily on technological approaches?
- Can changes in statewide and metropolitan planning contribute in a meaningful way to sustainability? Are changes needed in land use and urban form at the regional and neighborhood levels? Is basic planning reform feasible to the extent that regional planning can contribute to sustainable mobility?
- Can American society, through education and marketing, achieve a sufficient shift to more sustainable modes of transportation, including walking, cycling, and public transit use, to warrant an increasing focus on such strategies in our approach to sustainability?
- Should pricing be used to a much greater extent to internalize the externalities of transportation in order to approach a more sustainable transportation system?
- Can American transportation policy adopt more direct approaches to regulating travel choices and behavior? If such approaches are adopted, can they produce sufficient progress toward sustainable mobility to make them worth the costs of undertaking?

Answers to these questions will be key to the sustainability debate that will characterize American transportation policy for many years to come. The questions may have answers applying in the short term different from those applying in the longer run. At one level, they can be answered rather superficially. It is, for example, possible to respond that the attainment of sustainable mobility will require progress simultaneously in all of the areas delineated by these questions. But it is not realistic to think that society can forge ahead with equal vigor and with equal probability for success in all of these dimensions. At the other extreme, it is equally possible to conclude that most progress made to date has been the result of technological innovation and change and that it is logical to presume that technological change is the only promising path by which to approach sustainable mobility in America. In all likelihood, these two extreme positions are both unsatisfactory. Selecting the right mix of approaches is in the end a complex tech-

nical, political, and moral question. It requires that we consider what is feasible given American political organization and values, but it also requires us to balance what is internally feasible against what is likely to be happening in the rest of the world.

I doubt that we will be able to come up with final answers to these questions in the discussions that follow, and I expect that we will reconsider these questions many times over the coming decades. I hope that formulating the questions in these ways is a useful contribution to the debate that will follow in our workshops and in many other forums to come.

Acknowledgments

I benefited greatly from comments made on an earlier draft of this paper by Jennifer Dill, Richard Gilbert, John Pucher, and Daniel Sperling. I owe several of the ideas contained in this draft to their helpful suggestions.

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Committee Member Biographical Information

David L. Greene, *Chair*, is Corporate Research Fellow at Oak Ridge National Laboratory. He has long been regarded as a leader in sustainability as it pertains to transportation. He has spent 25 years in researching transportation energy and environmental policy issues. His research interests include analysis of policies to mitigate greenhouse gas emissions from transportation, the development of theory and methods for measuring the sustainability of transportation systems, the modeling of energy demand, economic analysis of petroleum dependence, and the modeling of market responses to advanced transportation technologies and alternative fuels. Dr. Greene has been active in the Transportation Research Board (TRB) and the National Research Council for more than 25 years and has served on several standing and ad hoc committees dealing with energy and environmental issues and research needs. He is past chair and an emeritus member of TRB's Energy Committee, past chair of the Section on Environmental and Energy Concerns, and a recipient of the TRB Pyke Johnson Award. Dr. Greene is a lifetime National Associate of the National Academies. He was a U.S. participant in the second and third assessments of the Intergovernmental Panel on Climate Change as a lead and contributing author.

Dr. Greene received a B.A. from Columbia University, an M.A. from the University of Oregon, and a Ph.D. in geography and environmental engineering from the Johns Hopkins University. After joining Oak Ridge National Laboratory, he founded the Transportation Energy Group and later established the Transportation Research Section. He has published more than 150 articles in professional journals, contributed to books and technical reports, and authored or edited three books (*Transportation and Energy*, *Transportation and Global Climate Change*, and *The Full Costs and Benefits of Transportation*). He served as the first editor-in-chief of the *Joumal of Transportation and Statistics* and currently serves on a number of editorial boards, including that of *Energy Policy*.

William R. Black is Professor of Geography and Public and Environmental Affairs at Indiana University. After receiving his doctorate from the University of Iowa, he joined the faculty of the Department of Geography at Indiana University. He also taught at Miami University of Ohio and Purdue University. At Indiana University he served as Director of the Center for Urban and Regional Analysis, Chairman of the Urban and Regional Analysis Faculty, Chairman of the Department of Geography, and Acting Director of the Transportation Research Center. He is currently serving a second term as Chairman of the Department of Geography. He directed rail planning for the state of Indiana during the rail restructuring in the Midwest and Northeast United States in the 1970s. Subsequently, he served as a member of the Philadelphia-based activation task force that created the Consolidated Rail Corporation (better known as Conrail) in 1976. He served as the first Director of the Indiana Department of Transportation in 1980.

Dr. Black has been a transport adviser to the state of Indiana for the past 30 years, and he is the recipient of a Sagamore of the Wabash Award from that state for his public service. He has been a member of TRB for more

than 30 years. He served for 6 years as Chairman of the TRB Social and Economic Factors of Transportation Committee. He continues as a member of that committee, the International Activities Committee, and the Task Force on Sustainable Transportation. He served two terms as Chairman of the Transport Research Group of the Association of American Geographers (AAG) and is the 1995 recipient of that group's Edward L. Ullman Award for contributions to transport geography. He presented the Fleming Transportation Lecture at the 2000 meeting of AAG. From 1995 to 1998 he was North American Associate Editor of the *Journal of Transport Geography*.

Dr. Black continues to serve on the journal's editorial board as well as the boards of two international environmental journals. He is currently Coordinator of STAR, a National Science Foundation thematic research network on sustainable transport, and North American Coordinator of STELLA, a thematic research network on sustainable transport of the European Commission. He has directed 20 research projects for state and federal transport agencies. He is the author or coauthor of five books and the principal author of more than 150 research papers and reports. His current research interests are in the areas of sustainable transportation, indicators of sustainability, environmental impacts of transport, state and regional flow modeling, the use of network autocorrelation analysis for examining motor vehicle accidents, and full-cost analysis of alternative modes.

David G. Burwell is a Senior Fellow in the Prague Institute of Global Urban Development, a Washington think tank, where he is an observer of transportation and environmental policy. He was President and CEO of the Surface Transportation Policy Project (STPP), a nationwide network of more than 250 organizations devoted to improving the nation's transportation system. He directed STPP's New Directions Initiative, a multiyear campaign that makes federal and state transportation policies better serve families and communities. Mr. Burwell cofounded STPP and served as its chair from 1990 to 1997.

Mr. Burwell was cofounder of the Rails-to-Trails Conservancy, a nonprofit organization devoted to the conversion of abandoned rail corridors to public trail use, and served as its president for 15 years. Mr. Burwell worked as legal counsel for the National Wildlife Federation, where he specialized in transportation, land use, and air quality issues. He has authored several books and articles on transportation law and policy. He was the initial recipient of the Transportation Achievement Award, an annual STPP award for outstanding achievement in transportation policies.

Thomas M. Downs was appointed President and CEO of the Eno Transportation Foundation in 2003. He has worked most of his life in transportation or general government. In a career that spans more than 30 years, he has served in general government as a city manager in the Midwest, as a White House Fellow, and as City Administrator of Washington, D.C. In transportation he has served as an Executive Assistant to the U.S. Secretary of Transportation, as Associate Administrator of the Federal Highway Administration (FHWA) for Planning and Budget, as Executive Director of the Federal Transit Administration, and as Director of the Washington, D.C., Department of Transportation. He has served as Chair of the Washington Transportation Planning Board, the metropolitan planning organization for the Washington metropolitan area.

Dr. Downs left the Washington area in 1988 to become the President of the Triborough Bridge and Tunnel Authority in New York City. He later served as the Commissioner of Transportation for the State of New Jersey. In that role he also served as Chairman of the New Jersey Transit Corporation. During this time he also served as Chairman of the Northeast Association of State Transportation Officials and as a member of the Executive Committee of the American Association of State Highway and Transportation Officials. He has also served as a member of the Executive Committee of TRB and on numerous advisory committees at TRB and the U.S. Department of Transportation. He was one of the founders of the I-95 Corridor Coalition and the regional E-ZPass coalition in New York.

In 1993 Dr. Downs was appointed Chairman and CEO of Amtrak, the nation's passenger railroad. He substantially completed the electrification of the Northeast Corridor and completed the purchase of high-speed train sets. He helped Congress create a $2.4 billion trust fund for the railroad. After leaving Amtrak, he became the CEO of the National Association of Home Builders (NAHB). He left NAHB to join the faculty of the University of Maryland, where he served as Professor and Director of the National Center for Smart Growth.

He is a Fellow of the National Academy of Public Administration and is the author of numerous articles and monographs. He has advanced degrees from the University of Missouri and the University of Kansas.

Richard Gilbert is an urban issues consultant who focuses on transportation, waste management, energy systems, and urban governance, with clients in North America, Europe, and Asia. He serves as transport consultant to the Paris-based Organisation for Economic Co-operation and Development (OECD) and to Civic Exchange, a Hong Kong–based think tank; as part-time research director of the Toronto-based Centre for Sustainable Transportation (CST); and as adjunct professor in the University of Sherbrooke's Faculty of Administration.

Dr. Gilbert received a Ph.D. in 1966 in experimental psychology and in an earlier career was a psychology professor and researcher. He taught at universities in the 1960s and 1970s in Ireland, Scotland, the United States, Mexico, and Canada and was associated with the Addiction Research Foundation of Ontario from 1968 to 1991. In the 1990s he taught graduate courses in planning and urban governance at York University's Faculty of Environmental Studies.

He served as a member of the councils of the City of Toronto and Metropolitan Toronto from 1976 to 1991 and as president of the Federation of Canadian Municipalities from 1986 to 1987. On retiring as a municipal politician, he became the first president and CEO of the Canadian Urban Institute, a position he held from 1991 to 1993, and has worked as an independent consultant since then.

Major reports published during the past 2 years include *Electrifying Hong Kong: Making Transport Sustainable* for Civic Exchange; *Soft Measures and Transport Behaviour* for Umweltbundesamt, the German Federal Environment Agency, and OECD; *Energy and Smart Growth* for the Neptis Foundation and the government of Ontario; *Policy Instruments for Achieving Environmentally Sustainable Transport* for OECD; and *Sustainable Transportation Performance Indicators* for CST (supported by four departments of the government of Canada).

Kevin E. Heanue consults on transportation planning, environmental analysis, organizational development, and related issues. He began his consulting practice after a 40-year career with FHWA. Clients have included TRB, the Eno Transportation Foundation, Cambridge Systematics, the Northern Virginia Planning District Commission, the American Highway Users Alliance, OECD, the Civil Engineering Research Foundation, and FHWA. Mr. Heanue has consulted on topics including induced travel, a bridge feasibility study, transportation research priorities, international freight movement, intermodal transportation, and the role of metropolitan planning organizations in planning for freight movements.

In his most recent assignment with FHWA, Mr. Heanue served for 8 years as Director of the Office of Environment. During this time he administered the statewide, intermodal, and urban planning programs of the agency, as well as the environmental programs and requirements relating to the National Environmental Policy Act, the Clean Air Acts, and the Clean Water Acts. In addition, he had a major role in the development and implementation of the Intermodal Surface Transportation Efficiency Act and in the development of the Transportation Equity Act for the 21st Century.

Mr. Heanue is active in TRB. He has served on numerous committees, research panels, and conference steering committees and on the Group 1 Council. He is founding chair of the Task Force on Transportation and Sustainability. He is a Fellow of the American Society of Civil Engineers and serves on the membership advisory review committee. He has been a member of the Road Gang since 1984 and was its chairman in 1998. He has been a member of Lambda Alpha, an international honorary land economics society, since 1990. He is a registered Professional Engineer in the District of Columbia.

Mr. Heanue recently served on the International Steering Group for the World Bank. He directed the Dublin, Ireland, Transportation Study from 1970 to 1971; in 1986 he served as a consultant to the World Bank in China. Mr. Heanue has traveled extensively on FHWA missions to Mexico, England, France, and Germany. Between 1989 and 1995, he represented the United States as a member of the Permanent International Association of Road Congresses Committee on Urban Roads. He served as the U.S. representative on the Asia-Pacific Economic Cooperation Urban Transport Forum from 1996 to 1998.

Mr. Heanue is the coauthor of a recently published textbook, *Road Ecology: Science and Solutions*. He received his B.S. in civil engineering from Tufts University (cum laude) and his M.S. in civil engineering from Georgia Institute of Technology.

Marianne Millar Mintz is Transportation Systems Engineer at Argonne National Laboratory. She has worked with several offices of the U.S. Department of Energy and with the Federal Emergency Management Agency. She is focused on evaluating opportunities and investigating the impacts associated with the deployment of advanced engine and fuel technologies into the light- and heavy-duty vehicle fleet, expanding and recalibrating transportation energy forecasting and impact assessment models, and developing methods to identify market segments and estimate the likely penetration of alternative- and flexibly fueled vehicles into the U.S. transportation fleet. She is Chair of TRB's Transportation Energy Committee. Ms. Mintz received a B.A. from the University of California and an M.A. from Loyola University, Los Angeles.

Arthur (Chris) Nelson is Professor and Founding Director of Graduate Studies in Urban Affairs and Planning at Virginia Polytechnic Institute and State University's Alexandria Center. Before this appointment, he served for 15 years as Professor of City and Regional Planning in the College of Architecture at Georgia Tech, where he was also appointed to the faculties in public policy and international affairs in the Ivan Allen College. In addition, he served in the Transportation Research and Education Center in the College of Engineering. He was an Adjunct Professor of Law at Georgia State University.

Dr. Nelson is recognized broadly for his work on the relationship between metropolitan development patterns and economic development, use and dependency on alternative transportation modes, and social equity. His work in metropolitan governance has shown the benefits of federal-style governance systems in managing growth and investment at the metropolitan scale. That has led to current work on the relationship between metropolitan planning organization voting structure and transit investment, with implications for long-term metropolitan economic development, social justice, and fiscal stability. Dr. Nelson is one of the world's leading experts on impact fees, especially transportation impact fees, and he has pioneered methods of calibrating impact fees to account for social and economic equity, location efficiency, and economic development.

Over the past two decades, Dr. Nelson's work has been supported by such organizations as the National Science Foundation; TRB; the Federal Transit Administration and other federal agencies; the Brookings Institution; the Lincoln Institute of Land Policy; the American Planning Association; numerous foundations; and local, regional, and state agencies. He has more than 150 publications to his credit. Dr. Nelson's students have won numerous national awards in planning, policy, and design, and he has won awards as teacher of the year, professional educator of the year, and researcher of the year.

John P. Poorman has 30 years of experience in transportation planning with the Capital District Transportation Committee (CDTC), where he has been Staff Director since 1981. CDTC is the designated metropolitan planning organization for the four counties containing the Albany and Saratoga Springs, New York, urbanized areas. CDTC was selected by the Association of Metropolitan Planning Organizations for its 1997 National Award for Outstanding Achievement and was selected as the 1997 Employer of the Year by the Women's Transportation Seminar of New York's Capital District.

Mr. Poorman has been Chairman of the New York State Metropolitan Planning Organizations (NYSMPOs) since 1995. NYSMPOs was selected by the Association of Metropolitan Planning Organizations for the 2000 National Award for Outstanding Achievement in Special Projects for its statewide shared-cost initiatives. He was a member of the Board of Directors from 1995 to 1998 and was Vice Chairman from 1996 to 1997.

Mr. Poorman has been an adjunct faculty member in the State University of New York at Albany's graduate Urban and Regional Planning Program, a member of the Board of Advisors of the Eno Transportation Foundation, a member of TRB's Executive Committee, and a member of the National Research Council's Surface Transportation Environmental Cooperative Research Program Advisory Board.

He is the recipient of a 1996 Environmental Fellowship from the German Marshall Fund of the United States to study European approaches to full-cost accounting of transportation impacts. From 1991 to 1992 he was Director of the Urban Planning Section of the New York State Department of Transportation (NYSDOT) as part of an executive exchange between CDTC and NYSDOT. In 1988 he was honored by NYSDOT, and in 1989 honored by New York State County Highway Superintendents. In 2003 Mr. Poorman was named "Ally of the Year" by A Regional Enterprise to Support Empowerment, Albany.

Mr. Poorman has a bachelor of arts in economics from Haverford College and a master of science in transportation from Northwestern University.

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Dr. Sperling is recognized as a leading international expert on transportation, energy, and environmental policy, particularly with respect to advanced vehicle technology and alternative fuels. In the past 20 years, he has authored or coauthored more than 160 technical papers and eight books.

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Dr. Sperling has testified numerous times to Congress. He has provided advice to various government agencies and has provided keynote presentations and invited talks in recent years at international conferences in Asia, Europe, and North America.

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ISBN 0-309-09418-6