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Transportation for Sustainability

An International Conference

May 6–8, 2015
Washington, D.C.

TRANSPORTATION RESEARCH BOARD

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Transportation for Sustainability

An International Conference

May 6–8, 2015
The Keck Center of the National Academies of Sciences, Engineering, and Medicine
Washington, D.C.

Jolanda Prozzi
Texas A&M Transportation Institute
Rapporteur

Sponsored by
Federal Highway Administration
University of California, Davis: National Center for Sustainable Transportation
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Preface

This E-Circular was developed from presentations at Transportation for Sustainability: An International Conference, sponsored by the Sustainability and Transportation Committee of the Transportation Research Board, a unit of the National Academies of Sciences, Engineering, and Medicine. See Appendix B for the Conference Program. The conference explored ways in which transportation systems can promote sustainability. Sustainable transportation is an international issue because transportation contributes to climate change and collective action is needed to truly advance sustainable transportation. Institutions and governments must support sustainability to meet sustainability goals and improve the future for everyone.

The conference was held May 6–8, 2015, in Washington, D.C., and brought together participants from several different countries, participating both in person and online. Several students attended the conference and many displayed posters at the student poster session. One of the goals of the conference was to develop potential new research ideas, which could form the basis for future research and TRB papers.

The conference included a keynote address highlighting the failures of the past and present transportation system, as well as a call to address climate change in the future and a plenary session that emphasized that global initiatives take effect when they are implemented in national frameworks and adapted locally. Speakers shared perspectives from the World Resources Institute, the World Bank, and the U.S. Department of Transportation. Breakout sessions also addressed solutions for sustainability problems, the programs of national transportation agencies, travel and trade, and transportation and climate change. The breakout sessions continued into the second day and covered topics such as sustainability tools, evaluation methodologies, and emerging technologies. Attendees were divided into working groups to discuss key findings and potential research needs that emerged during the conference. The focus areas of the working groups were developing countries, transportation practitioners, factors affecting the demand for transportation and the impact on sustainability, and government policies versus private initiatives. The closing plenary session summarized and highlighted the salient points that were discussed in the working groups.

The views expressed in this E-Circular are those of the individual workshop speakers and participants, as attributed to them, and do not necessarily represent the views of all conference participants; the planning committee; TRB; or the National Academy of Sciences, Engineering, and Medicine.

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OPENING SESSION

Setting the Stage

APRIL MARCHESE
Federal Highway Administration, presiding

April Marchese welcomed the audience and the webinar participants. The attendees and webinar participants included representatives from state, local, and national governments, universities and research centers, business, industry, and nonprofits. There were students from nearly 24 universities. In addition, there were participants from many countries, including China, Brazil, and Denmark; 100 abstracts were submitted, 40 of which were submitted by students.

Marchese encouraged participants to participate—the conference should be a dialogue, should be used to form new connections, and share ideas.

Marchese emphasized that sustainability is becoming a touchstone to improving the future, and transportation is a key element to achieving sustainability. Furthermore, the United Nation's Sustainable Development Program recognizes that international cooperation is needed to ensure that transportation systems support sustainable development.

INTRODUCTORY REMARKS

Monica Starnes, Senior Program Officer for Policy and Management and Transportation Research Board Coordinator for International Activities

Starnes welcomed participants on behalf of the director of TRB, Neil Pedersen, who was unable to attend. Starnes emphasized the importance of active participation by attendees. The theme of the 95th Annual Meeting of the Transportation Research Board is Research Convergence for a Multimodal Future, and she stated that the conference was a great place to develop ideas around that topic. She remarked that webcast participants were from Canada, Mexico, Austria, Brazil, Taiwan, and the United States. Starnes thanked the FHWA for supporting the webcast. Starnes concluded by encouraging attendees to attend the evening's poster session.

WELCOME ADDRESS

Joe Zietsman, Environment and Air Quality Division Head, Texas A&M Transportation Institute

Marchese then introduced Joe Zietsman. She mentioned that he does research on sustainable transportation, air quality, climate change, performance management, and is the chair of the Sustainability and Transportation Committee that sponsored the conference.

Zietsman remarked that he has been involved in the Sustainability and Transportation Committee, which was started by Dan Sperling, for more than 12 years. Zietsman thanked the organizing committee members—and in particular, Marchese and Starnes—and the sponsors: FHWA, AASHTO: Center for Environmental Excellence, U.S. Environmental Protection Agency, University of California, Davis (UC Davis), National Center for Sustainable Transportation, and Parsons Corporation.

Zietsman remarked that some abstracts, although good, were not selected because they did not fit within the theme of the conference. Zietsman encouraged the authors to develop a full research paper and submit it to TRB by August 1.

Zietsman concluded his remarks by emphasizing the three goals of the conference: (1) good technical work and solid presentations, (2) international perspectives, and (3) development of research ideas and research proposals.

KEYNOTE ADDRESS TO SET THE STAGE

Dan Sperling, Distinguished Professor and Founding Director, Institute of Transportation Studies, University of California, Davis

Marchese introduced Sperling. Sperling has launched several research centers, including the Energy Efficiency Center at UC Davis, led the drafting of the transportation section of the Intergovernmental Panel on Climate Change Report on Mitigation of Climate Change, and authored or coauthored numerous papers and books, including *Two Billion Cars*. He was awarded the Blue Planet Award in recognition of his ability to bring together academia, industry, and government to develop new approaches. Overall, he strives to bring science to policy.

Sperling started his remarks with a historical note on sustainability. In the 1990s, sustainability was an anathema to the transportation community. Tom Dean, then-Executive Director of TRB, created a Committee on Transportation and Sustainability. Sperling recalled how difficult it was to define sustainability during the first 6 months of the committee's existence. After 6 months, the committee abandoned defining sustainability and decided to list the environmental impacts of transportation; not considering the social and economic impacts. Today, there is a general understanding that sustainability does not only consider environmental impacts. Sperling's presentation highlighted the following:

- Cities and lifestyles that emphasize cars. Los Angeles pioneered car-centric cities and lifestyles. Over the past 10 years, the state of California introduced legislation to reduce the impact of cars and create a more sustainable transportation system.
- Unsustainable practices. Sperling showed two images depicting unsustainable practices. The first showed the Interstate 110 and Interstate 105 interchange near Los Angeles, a web of highway lanes and high-occupancy vehicle (HOV) flyover lanes. The second showed a person walking a dog while driving a car. If the dog owner was walking the dog, he would exercise and there would be fewer emissions associated with "walking" the dog.
- Car monoculture. Carpooling numbers were decreasing and public transportation accounts for 3% of personal-miles traveled (5% of trips). Essentially, public transportation serves dense city centers. The car-centric model of the United States is being imitated in cities around the world. For example, Brasilia was built around cars.
- Expensive and resource-intensive highway infrastructure system. In the United States, more than $100 billion is spent per year on road infrastructure. It costs $9,000 per year to own and operate a car ($1 trillion per year for all cars). The United States spends around $500 billion on oil per year. One third of the greenhouse gases (GHG) and half of urban air pollution in the United States are attributable to cars. Sperling noted that, globally, transportation accounts for one-quarter of carbon dioxide emissions, half of all oil use, and half of the urban air pollution.
- Building a 21st century transportation system with 20th century institutions and

budgets. Sperling noted that the transportation profession has its origins in civil engineering. Traditionally, the transportation field focused on building supply to meet forecasted demand. Sperling emphasized the importance of the social and environmental sciences and information and communication technologies to move beyond the civil engineering paradigm.

- Creating cheaper, better, more sustainable transportation systems. Sperling remarked that future transportation systems should be less resource intensive and more accessible. Accessibility is important because it allows more people to contribute to society.
- Too much fossil energy. The transportation industry needs to address climate change. Oil is not inexpensive and abundant. Technologies that make it easier to extract fossil energy exacerbate the problem of reducing carbon. The climate cannot absorb so much carbon. Sperling noted that there has to be a shift away from high-carbon fossil fuels.
- Innovations in the auto industry. Sperling remarked that internal combustion engine vehicles improve in efficiency by about 4% each year. The national 54-mpg standard rule will be in place through 2025. Policy makers and industry are thus aspiring to improve the fuel efficiency of vehicles.
- Reduce vehicle use. Sperling showed a graphic that illustrated that passenger light-duty vehicle travel (travel demand per capita) in select Organisation for Economic Co-operation and Development (OECD) countries has peaked. The reasons seem to be economic, environmental, and related to health and equity concerns. A reduction in vehicle use reduce road and infrastructure costs, air pollution, oil use, GHG emissions, and improve social equity and livability.
- Demand management policies have failed. Sperling remarked that HOV lanes have largely failed, because fewer people are carpooling. Conventional transit (buses and rail) also performs poorly, because it is expensive (60% of metro transport budgets for less than 10% of trips) and it is not reducing GHG emissions. Bus rapid transit (BRT) is not practical for low-density areas (such as, the Central Valley of California) because it is too costly; vouchers would be more practical than new bus routes.
- California's Sustainable Communities Act of 2008 (SB 375). SB 375 sets GHG targets (associated with passenger vehicle use) for all cities. It provides a single, simple metric. Reducing GHGs also reduces infrastructure costs and supports healthy communities. It is revolutionary, because it ties funding to reducing vehicle-miles traveled (VMT). The funding can be used to invest in transit and bicycle infrastructure.
- Bringing information and communication technologies to the transportation sector. Transportation needs to be more innovative. The structure of the transportation system has barely changed in the past 50 years. The transportation modes and funding mechanisms are, in essence, the same. However, if there are more transportation choices, then it is more likely that people would give up cars.
- New mobility services could capture over 30% of passenger travel and increase transit ridership. Uber and Lyft can be more than glorified taxis. New mobility services would serve people unable to drive, prefer not to drive, experience an emergency, people interested in saving money, and people who want to use their travel time productively. The public benefits of new mobility services include less vehicle use and improved access for the mobility disadvantaged (e.g., the handicapped, the elderly, and the poor).Currently, the transportation community is not playing a role in new mobility services.
- Sustainability solutions are needed for freight transport. Sperling indicated the need for a sustainable freight transportation system, because distribution centers are sprawling and consumers are starting to demand same day delivery.

- Four sustainability strategies. Sperling offered four sustainability strategies:
  1. Switch from high-carbon fossil energy and improve energy efficiency of vehicles;
  2. Reduce vehicle use and create more livable communities;
  3. Improve the sustainability of freight; and
  4. Adapt infrastructure and land development to a changing climate.

Sperling concluded his presentation by stating that climate change is a challenge that needs to be addressed at all levels of government and that success will require partnerships between universities and government. The challenge is to determine how policy alters consumer behavior and stimulates innovation. This will require science in policy.

QUESTIONS AND ANSWERS

Gary McVoy, McVoy Associates: We need to talk about transportation in support of a more sustainable society.

Sperling: Transportation is generally local. Transportation is a system, which can be dealt with from a bottom-up and a top-down approach. [Sperling encourages his students to work for government to help make the changes necessary to shift the paradigm.]

Todd Litman: Transportation demand management (TDM) and conventional public transit have not necessarily failed. Effective TDM strategies include parking management and pricing. Residents of cities with high-quality public transportation have far lower per-capita vehicle ownership and far lower per-capita vehicle travel. We need to shift from measuring mode share to measuring per-capita VMT. There is value in investing in conventional bus service.

Sperling: We need to figure out how to support conventional transit better, both in terms of land use and mobility.

Stewart (online): Is the climate not going to change faster than our responses?

Sperling: Essentially, it is better to do something as opposed to nothing.

Regina Clewlow, Stanford University: What do you think about the convergence of shared-use and autonomous vehicles in the future?

Sperling: There is little data on Uber and Lyft. The companies do not want to share data for proprietary reasons. TDMs should include ride-sharing services. Policy should help Uber and Lyft become more like transit, less like taxis. [Sperling does not expect true automated vehicles to emerge for several decades, because theses modes will be highly regulated.]

Yannick Cornet, Technical University of Denmark: It would be interesting to compare GHG emissions per capita versus VMT per capita. On a separate issue, in Copenhagen, cycling represents 42% of the mode share. How do we increase bike ridership in the United States?

Sperling: Although there is a newfound enthusiasm for bikes, bicycle infrastructure still represents a small percentage of transportation budgets. Cycling will not be a very practical option until there is infrastructure to protect cyclists from cars. More funding is needed.

Roger Venables, CEEQUAL: What is the role of transporting freight and people in a more sustainable way?

Sperling: We need government, industry, and universities working together. We need to focus on enforcement of new programs, not just forecasting.

David Proffitt, University of Utah: How do we bridge the gap between government and research?

Sperling: [Sperling created a Policy Institute to address this issue.] The Policy Institute briefs legislators and government agencies. Webinars, two-page policy briefs, and white papers (longer than two pages, but still synthesis documents) are important to deliver compact information. There is a lack of trust as the two entities have different priorities. Government workers are concerned about privacy and how they represent their employer. Researchers are concerned about academic integrity. During sabbaticals, researchers could work for government agencies and learn more about how government works.

Although there were more questions, the discussion was concluded in the interest of time.

PLENARY SESSION

Global Initiatives

HENRIK GUDMUNDSSON
Technical University of Denmark, presiding

Henrik Gudmundsson gave the introduction to the plenary session. He emphasized that transportation has been addressed traditionally as a local issue and also a national issue. Now it has become a global issue, because it has a tremendous impact and transportation systems are interconnected. More than half the world's population is living in cities and several billion metric tons of carbon dioxide are emitted each year. We have global problems, but not global solutions.

In 2012, at the Rio+20 Conference, the nations of the world recognized the significance of transportation for sustainability. Also, in 2012, multilateral development banks pledged more than US$175 billion in loans and grants to support sustainable transportation in developing countries. Following the Rio+20 Conference, an open working group was established to develop sustainable development goals. Several of the targets and indicators of the 17 goals that were developed are related to transportation.

In 2014, United Nations (UN) Secretary General Ban Ki-moon launched a high-level advisory group on sustainable transportation to provide actionable recommendations applicable to global, national, and sector levels. This is an exciting period for sustainable transportation and climate change. In April 2015, there was a conference organized by the Vatican and the UN on the Moral Dimensions of Climate Change, and leaders of science, politics, and religion attended. In 2015, there will be a UN General Assembly which might support additional sustainable transportation outcomes. Also, in December 2015, the 21st Conference of the Parties to the UN Framework Convention on Climate Change took place in Paris. In 2016, a Habitat III Conference in Ecuador will focus on human settlements and cities.

Gudmundsson emphasized that the global, local, and national levels must work together. Global initiatives only take effect when they are implemented in national frameworks and adopted locally. Gudmundsson encouraged the speakers to address how global initiatives influence the transportation agenda; especially with regard to sustainability.

Holger Dalkmann, Director, Strategy and Global Policy, EMBARQ Director, World Resources Institute (WRI) Ross Center for Sustainable Cities

Dalkmann's presentation was entitled "A Year of Global Events: Key Global Development Opportunities in 2015." Dalkmann began with a photo from Bangalore, India, which showed the metro station, cars, and a lack of infrastructure for pedestrians. The metro is still under construction, even as millions of people are moving to Bangalore. He emphasized that when we talk about international processes it is important to think about people and linking them in an area. Most of our work is not about international processes, but actually on the ground with cities to work on their frameworks. Cities have to change themselves; international processes will not effect changes in cities.

The UN Secretary General Climate Summit was held in September 2014 to mobilize

political will leading up to the conference in Paris in 2015 (i.e., 21st Conference of the Parties to the UN Framework Convention on Climate Change, Paris). It will be an important venue for countries to discuss how they will address climate change.

Dalkmann noted the formation of a Green Climate Fund to mitigate and fund adaption strategies given climate change. This fund could potentially make $1.4 to $1.7 trillion per year available for transportation infrastructure. This can be an investment incentive, but will not completely change things.

The UN Secretary General commitments include the following:

- Compact of Mayors. Mayors have gathered to get cities to report on one standard, set targets as cities, and commit to action. As a result, Mexico City has a climate action plan.
- International Organization for Public Transport Authorities and Operators (UITP). The UITP wants to reduce the carbon footprint of public transportation by 25%.
- International Union of Railways (UIC). The UIC supports low-carbon sustainable rail transport.
- Urban Electric Mobility Vehicles Initiative. This UN program focuses on increasing the share of electric vehicles.
- Financing for Development, Addis Ababa, Ethiopia. The focus will be on low-income countries, and consider how cities that have not yet been built can develop sustainably.

Dalkman also reviewed the UN Sustainable Development Goals. He mentioned that the eight Millennium Development Goals were changed to 17 Sustainable Development Goals in 2012 to include sustainability and to be more universal. Sustainable transportation is not a goal, but sustainable transportation is addressed in seven out of the 17 goals. The means for implementing the goals have, however, not been decided.

Finally, Dalkmann mentioned that the Habitat III (Quito, Ecuador) will develop a new paradigm for cities.

Dalkmann concluded that these international processes will not solve the issues surrounding sustainable mobility. However, these international processes raise awareness and include funding. The right investments can make a difference. These policy frameworks are even better when supported by research.

Jose Luis Irigoyen, Director, Transport and ICT Global Practice, World Bank

Irigoyen provided a background on world transportation needs. Irigoyen highlighted the following:

- World transportation needs are growing rapidly. More transportation activity is taking place in the developing world than in the developed world. The volume of transported passengers and freight has increased dramatically in developing countries. Half of the world's population will be middle class by 2030. Currently, 1 billion people do not have access to an all-weather road.
- Rapid urbanization is changing the face of the planet, and scale and speed are factors. It is hard to plan urban development when it occurs so quickly, but it is possible to plan for sustainability from the beginning.
- Megacities are congested at low motorization rates. Policies can promote the same

level of mobility with less car use.

- Road safety crisis. Globally, road accidents are the eighth leading cause of death. It is an equity issue in the developing world. In the developing world, 50% of the fatalities are pedestrians.
- Climate change is a threat to development in our lifetime. Climate change has had a fiscal impact on several countries due to natural disasters. Transportation contributes almost 25% of carbon dioxide emissions, and the sector's contributions are increasing. Sustainable transportation policies generally focus on changing behaviors that are based on individual everyday decisions. The larger transportation sector needs to play a role. It is important to study how developing countries are developing and whether they can develop more sustainably.
- Emerging trends. Local issues have become national and global issues. The best place to visualize this is in cities. In cities there is local traffic and pollution. Cities affect the nation. Urban transportation has been recognized as a global issue.
- The World Bank. International Development Association projects are analyzed for climate and disaster risk, and GHG accounting is in place, which uses the social value of carbon. The World Bank is funding many roads that promote green initiatives and is paying increased attention to waterway transportation.
- Sustainable development goals and finance for development. The 17 Sustainable Development Goals (SDGs) imply action around the world on sustainability, and are an improved version of the Millennium Development Goals. Actions such as reducing congestion will have many positive benefits.
- Challenges and knowledge gaps to implementing SDGs:
  - Technical data and indicators are needed. As an example, we need to know how people get around and why.
  - Evidence- and data-based packages and policies are needed to support Intended Nationally Determined Contributions and road safety action plans.
  - More-comprehensive appraisal methodologies are needed to value benefits. An example is scenario planning when dealing with uncertainty. It is important to measure qualitative impacts.
  - A better understanding of the determinants of behavior is needed. An understanding of human behavior should be a component of effective legislation and policies. The 2015 World Development Report from the World Bank, *Mind, Society, and Behavior*, emphasizes how important it is to understand how people make decisions.
  - Strong and diverse coalitions at the national, global, and local levels are needed, because the local and global realms are connected and coalitions can help us be more effective.
- Changing behaviors and managing for results. Irigoyen used the example of road safety in Spain to show how it became important to society to reduce road fatalities. Society eventually pushed the government to develop policies to address road fatalities. Spain was able to dramatically reduce the number of road fatalities.

Shoshana Lew, Deputy Assistant Secretary for Transportation Policy, U.S. DOT

Lew presented the sustainability efforts of the U.S. Department of Transportation (DOT):

- *Beyond Traffic 2045: Trends and Choices.* The report released by U.S. DOT

addresses the pressure of growing infrastructure and climate change on the transportation system.

- The President's Climate Action Plan
  - Leads the international effort to combat climate change,
  - Prepares the United States to adapt to the impacts of climate change, and
  - Mitigates carbon emissions.
- International commitments of the United States include the following:
  - Post-2020 climate target for the United States and China is to reduce emissions 26% to 28% below 2005 levels by 2025. This will require a reduction in transportations emissions as transportation is responsible for 28% of all U.S. emissions.
  - International collaboration involves many partners, including the International Civil Aviation Organization (ICAO). Fuel economy standards are an important component of this collaboration to reduce emissions; particularly the emissions associated with cars and trucks.
- Climate mitigation: one goal is increasing efficiency:
  - Corporate Average Fuel Economy (CAFE)/CO_2 Emissions Reductions Standards in the United States is a joint effort between the U.S. DOT and EPA.
  - Light-duty vehicles target is to double the average new vehicle fuel economy by 2025:
    - This will save 2.2 million barrels of oil a day, result in $1.7 trillion in savings, and reduce emissions by 6 billion metric tons over the lifetime of vehicles sold during the period.
    - Data from 2014 show that fuel economy reached its highest in 2013—24.1 mpg, which is more than 0.5/gal difference from the year before.
  - Target for medium and heavy-duty vehicles (vans, pickups, trucks, tractors)
    - Will save 530 million barrels of oil, reduce emissions by 270 million metric tons, and
    - Is on track to meet standards by 2016, when there will be a second round of standards for medium and heavy-duty vehicles.
  - Cooperative efforts among agencies, industry, and labor: flexibility, long-term goals, and interim targets have been important.
  - Next-Generation Air Transportation System (NextGen): a systems approach focused on increasing the efficiency of aircraft.
  - U.S. Aircraft Standards (a component of ICAO negotiations) should save 5.8 billion gallons of fuel through 2030.
- Climate mitigation: another goal is increasing transportation choices:
  - U.S. DOT is focused on providing more-sustainable and low-emission options;
  - A 76% increase in funding for transit is proposed;
  - Passenger rail, bike, and pedestrian initiatives are under way;
  - Increasing freight system efficiency and encouraging low-carbon movement; and
  - Studying whether switching to liquefied natural gas would be effective for various freight modes (marine, rail, trucks).
- Climate adaptation and resiliency—effects on the transportation system:
  - Damage to assets: flooding of subway tunnels, destruction of roads, and heat kinking rail;
  - Impacts on operations: weather delays, mode switching, traffic signal failure, safety–congestion impacts;

  - Nationally significant infrastructure: critical corridors, petroleum systems, Great Lakes and Mississippi Valley waterways; and
  - Health impacts: heat and public transit, vulnerable populations, spread of disease.
- Climate adaptation and resiliency:
  - Federal transportation funding can often be used for adaptation and resiliency components of transportation projects and
  - In many cases, adaptation and resiliency efforts are required for state and local plans and projects.
- Resiliency in the GROW America Act:
  - $478 billion funding over 6 years for surface transportation.
  - Propose policy changes, such as a more-robust planning processes to promote resiliency.
  - Example: CMAQ program of FHWA addresses air quality.
- Research and Tools: Gulf Coast Studies:
  - 2008 Gulf Coast Study (FHWA) looked at the region and risks to key transportation facilities.
  - 2015 Gulf II Study focused on Mobile, Alabama.
  - Good example of how to use climate data in risk assessment.
  - Tools developed:
    - Coupled Model Intercomparison Project Climate Data Processing Tool: Excel-based, with 58 temperature and precipitation variables relevant to transportation and
    - Vulnerability Assessment Scoring Tool: spreadsheet, provides a framework for conducting a vulnerability assessment.
- Research and Tools: INVEST (FHWA):
  - A free web-based self-assessment tool that
    - Considers the economic, social, and environmental outcome of sustainable transportation and
    - Three modules: systems planning, project development, and operations and maintenance.
- Environmental and Community Sustainability: Partnership for Sustainable Communities (HUD, DOT, EPA):
  - Creating ladders of opportunity: facilitating the connectivity of people and
  - Policies that are beneficial to the climate can also be beneficial to people in their daily lives.

QUESTIONS AND ANSWERS

Gudmundsson began with a brief reflection of the points raised by the speakers. Lock-in and choice were two key words mentioned by speakers. Sustainability is complex, and simple metrics may be needed tie it all together. Can we improve sustainability incrementally, or do we need to take broader leaps?

Todd Litman, Victoria Transport Policy Institute: Good research needs good data. The Global Transport Intelligence Initiative is trying to develop standardized data so that researchers

can look at relationships across cities across the world, for example, how to categorize vehicles, travel activity, etc. There are many members, but the U.S. DOT is not a member. What can we do to get the U.S. government and its partners on board? The U.S. DOT has collected a lot of excellent data sets over the years, but the data is not using the same international standards.

Shoshanna Lew: The administration is interested in bringing datasets together.

Beth Zitler, Energy Board of the National Academies: Who or what is funding the infrastructure projects in the least-developed countries?

Jose Luis Irigoyen: The World Bank contributes $5 to $7 billion to the transport sector every year, and multilaterals contribute around $17 to $18 billion, and together they represent 30% of flow. The majority of funding comes from governments, but lately there has been more funding from the private sector. The World Bank would like to devote $100 billion to climate change in the next several years. The Word Bank would like to provide more funding for transportation and climate change.

Gudmundsson: We cannot necessarily judge the impact of the funding based on the amounts. It's interesting to think about the snowball effect of funding.

Kevork Hacatoglu, Ministry of Transportation, Ontario, Canada: In Ontario, 30% of GHGs are from the transportation sector. In Canada, there appears to be more sales of light-duty trucks and SUVs. Light-duty trucks are classified differently than cars. Is there an initiative to reduce the growing number of light-duty trucks (which would include SUVs)?

Lew: Light duty trucks have the same set of standards as cars. Regulation of medium- and heavy-duty trucks was unprecedented before the current administration.

Gudmundsson: Maybe the question on standards for SUVs is too technical for this context.

Question from web: Can freight demand be managed?

Jose Luis Irigoyen: The World Bank has a partnership with the Dutch on sustainable logistics. Urban logistics is an issue as Internet shopping has increased the number of trips. Coalitions involving industry are important.

Holger Dalkmann: Unlike the passenger sector, there is little discussion on demand in the freight sector. Buying local is not always the best option. There needs to be more research, and consumers need more guidance on what are the right choices for sustainability.

Irigoyen: In the urban context, the demand side of the equation needs to be addressed.

Philippe Crist, OECD, Paris, France: There has been a lot of talk on choice, but at what point do we introduce restrictions and constraints? There are examples around the world, such as lotteries for new license plates and congestion pricing limiting access to city centers. Will the United States be able to achieve its goals without limiting choices?

Dalkmann: Global fuel subsidies are not helping people make sustainable choices. National governments can address parking. What places like Paris are doing is not restriction (even though they are restricting cars), they are focusing on opening opportunities for *people*. The pricing should be framed as "making the city for the use of people."

Lew: The United States' long-term strategy is tied to the notion that the infrastructure we want is associated with costs. The idea that it costs money to create the choices we want is very important.

Sperling: [Sperling spoke to the issue raised by Hacatoglu on the issue of fuel economy standards for light-duty trucks and cars] The problem is that cars and light trucks have different fuel economy standards. There is favoritism for cars over light trucks. A footprint-based approach to fuel economy standards provides no incentive for downsizing for cars, though there are incentives for lighter weight materials. Others (Europe, Japan, China) use a weight-based approach so there is an incentive for downsizing, but not making lighter vehicles. The best thing would be to have one point for a standard. These measures are not totally helpful because they only measure emissions out of the tailpipe and are not looking at the supply chain of it (batteries and aluminum are very energy-intensive). When using biofuels, electricity, etc., most of the emissions are upstream. We need a new regulatory regime.

In terms of freight, there is hardly any data. We have enough data to know that logistics sprawl is happening—warehouses are moving further out. But at the same time, consumers want delivery in the same day, which increases demand for trucks. Real-time tracking of inventory is in high demand, which increases freight VMT. Most freight trends are going in the wrong direction. There has been more work in Europe on freight efficiency, such as consolidation across companies in terminals, and last-mile delivery, but even there the work is pretty preliminary. More research is needed on freight.

BREAKOUT SESSION 1

Assessing Solutions for Common Sustainability Problems

JENNY O'CONNELL
American Association of State Highway and Transportation Officials
Standing Committee on the Environment, presiding

SOCIAL, ENVIRONMENTAL, AND ECONOMIC BENEFIT OF BUS RAPID TRANSIT: CASE STUDIES FROM COLOMBIA, MEXICO, SOUTH AFRICA, AND TURKEY

Juan Velasquez, EMBARQ

- BRT:
  - Now in more than 200 cities worldwide; programs of note include Lima, Curitiba, Bogotá, and Guanghou.
  - Benefits: high carrying capacities (similar to metro systems), flexible, works well in developing countries, cheaper than metro or rail.
- Benefits of BRT:
  - Travel time is reduced. There is a segregated lane, so buses are not affected by car traffic; buses stop at stations with level boarding and multiple doors; prepaid payment.
  - Costs and emissions. Consolidates public transit demand to one lane which reduces operation costs; can be implemented fairly quickly; lower emissions are associated with newer buses.
  - Safety. Segregated lanes mean less interaction with mixed traffic, and accidents are less likely; a reduction in VMT for buses means a reduction in accidents.
  - Physical activity. People are more likely to walk to BRT stations, which is beneficial for their health.
  - Land use is harder to evaluate, but mass transit can be a tool to encourage people to use transit and walk more, instead of using private vehicles.
  - Property values. Usually there is a positive correlation between proximity to BRT stations and property values.
- Case studies:
  - Bogotá cost–benefit analysis:
    - The greatest benefits were reduced transit travel time and reduced transit operating costs.
    - In terms of equity, the greatest benefits of BRT were for the middle class and lower middle class.
- Summary:
  - The benefits were not as great for people of the highest income groups, mainly because they pay a lot in taxes in some countries and do not utilize BRT very much.
  - As incomes grow, it is important to make transit attractive to upper income people so that they do not choose to utilize private cars.
  - In addition, the costs and benefits of BRT to the lowest income groups also need to be addressed.

DEVELOPING AN ASSESSMENT MODEL FOR SITE SELECTION OF AFFORDABLE HOUSING COMMUNITIES IN RAIL TRANSIT CORRIDOR OF KAOHSIUNG, TAIWAN

Kang-Li Wu, Harbin Institute of Technology

[Note: Wu's talk on affordable housing site selection was not included in the taped portion of the session. Notes taken during the session are below.]

The researchers tried to answer three research questions and promote social equity in Chinese cities. Rapid urbanization is occurring in China, and urban and suburban sprawl is an issue. There is a mismatch between transportation supply and housing development.

Transit-oriented development (TOD) can be combined with planning for social equity to promote sustainable urban planning and design. In China, there are many opportunities and challenges. More affordable housing is needed; people have to work 50 years to buy a house.

A case study was presented for Kaohsiung. The assessment framework consisted of accessibility, location characteristics, population and housing, land use, ecologic and environmental quality, and social and community characteristics such as crime rate and community identity.

The indictors were combined with geographic information system data on the spatial distribution of the population, greenspace, housing price, and land use density and intensity.

The researchers found the assessment model is useful for decision making and for public debate. The methods can be modified and used for other Chinese cites. They hope that TOD is not just used for infrastructure investment, but also as a tool to plan for social equity.

EVALUATION OF MTC'S CLIMATE INITIATIVES PROGRAM

Stephanie Hom and Ursula Vogler, Metropolitan Transportation Commission of the San Francisco Bay Area; Jeffrey Ang-Olsen, ICF International

Hom began with an overview of the regulatory framework that led to the Climate Initiatives Program.

- AB 32: Global Warming Solutions Act of 2006 requires GHG emissions in California to drop to 1990 levels by 2020, and supports an 80% reduction in GHG emissions by 2050.
- Senate Bill 375: Sustainable Communities Strategy (SCS):
  - Bay Area needs to reduce its GHG by 15% by 2035.
  - SCS integrates transportation and land use.
  - Plan Bay Area: a regional transportation plan and SCS to address GHG reductions.
- Goals of Metropolitan Transportation Commission's (MTC's) Climate Program:
  - Meet SB 375 emission reduction requirements.
  - Test innovative transportation strategies and technologies, such as transportation demand strategies.
  - Promote cobenefits such as improved public health and reduced transportation costs.
  - Replicate successful projects throughout the region.
- Plan Bay Area Climate Program. Invests $630 million over 25 years in vanpool

incentives, regional electric vehicle charger network, and commuter benefits ordinance.

- Cycle 1: TDM, parking pricing, Safe Routes to Schools.
- Most climate program activities reduce emissions by reducing VMT, or by deploying cleaner vehicles.
- TDM Projects.
  - Connect, Redwood City: car sharing, bike sharing, vanpools, telework and flex-schedules. Likely effective because of the targeted outreach. There was a comprehensive website.
  - Go Berkeley: dynamic parking pricing, transit pass program, car sharing, marketing
  - Dynamic ridesharing application in Sonoma, Marin, and Contra Costa counties.

Vogler continued the discussion of MTC's programs.

- Bike projects:
  - Bike mobile (visits schools and community centers to provide free bike repairs and safety education). Lead to an increase in bike use and thus a reduction in GHG emissions.
  - Bay Area Bike Share. Emission reductions were not as great because vehicles are required to move bikes so that they are evenly distributed at stations.
- Electric vehicles through City Car Share. Education is key—people need to know that the vehicles need to be recharged.
- Cold-in-place paving. Repaves roads by recycling the pavement on the spot. So cost-effective that it makes money.
- Shore power. Ships are plugged in when they come into port. In use in the Port of Oakland.
- Enhanced automatic vehicle locator system. Used within the Santa Rosa city bus fleet.
- Safe Routes to School. Encourages infrastructure to support students walking and biking to school; important for elementary and high school-aged youth.
- Smart driving. Real-time devices and applications that show the current fuel economy.
- Experience Electric. Encourages the purchase of electric vehicles (EVs) by allowing people to try them out and talk with EV owners.
- New initiatives and technologies that could reduce GHG emissions. Low rolling resistance tires, incident management, and autonomous vehicles.

CRITICAL ANALYSIS OF RESIDENTIAL NEIGHBORHOODS IN DELHI, INDIA

Amit Arora, Low-Emission Urban Development

- Short-distance trips can add up to considerable GHG emissions.
- There is limited data on short-distance trips in developing countries.
- Self-containment index reflects the availability of daily amenities.
- Entropy measures the extent to which groups are evenly distributed among organizational units. The higher the entropy index, the lower centeredness.
- Centeredness is the accessible distance to various facilities.
- Findings:
  - Studies indicate that the physical layout of a neighborhood affects the use of

sustainable transportation modes.

– Mobility levels (based on average trip length) tend to increase with decreases in diversity (measured by entropy).

– In India, bikes are only used by the extremely poor or by the upper class as a fashion statement.

QUESTIONS AND ANSWERS

From the web, Germano Johansen: When should light rail transit (LRT) be chosen over BRT?

Juan Velasquez: Both BRT and LRT provide similar capacity. LRT may provide a more comfortable ride (based on stopping and accelerating). Reorganizing routes and removing less-efficient vehicles can reduce emissions. LRT is more costly.

Jacob Perlstein: I think the question was about which—BRT or LRT—has a higher capacity.

Velasquez: I think BRT can have a higher capacity. If you want rail and want high capacity, you should look toward heavy rail.

Perlstein: What about preferential traffic signals for BRT?

Velasquez: Preferential signals are more important for low-capacity BRT systems.

Unnamed speaker: [Regarding the] breakdown of BRT cost–benefits based on income—why were there outliers in Johannesburg and Istanbul?

Velasquez: In Istanbul, the highest-income people use the system a lot, and all income groups positively benefit from BRT. In Johannesburg, where the BRT line is geographically located, there is already a lot of taxi use, particularly by upper-income people. Johannesburg is more of an exception to the normal outcome of a BRT system.

Question from the web: Given the high price of avoiding the CO_2 cited in MTC's presentation, what does the panel think of the current nominal social price of CO_2?

Stephanie Hom: The program is a pilot program, and moving forward we will use the most cost-effective metrics, and the best-performing projects. [Question not really answered. Jeffrey Ang-Olsen answered, but he did not use a microphone and what he said was inaudible.]

Todd Litman, Victoria Transport Policy Institute: How did MTC determine the cost–benefits of the programs? Did you divide the cost to the program by 1-year savings?

[The question was deferred to Ang-Olsen, but he did not use a microphone and what he said was inaudible.]

Litman: The overseas presentations emphasized an integration of public transportation and land use. But, the MTC did not mention an integration of public transportation and land use. What

about reallocation of road space, such as bus lanes? Could you speak to how the Bay Area could benefit from BRT and TOD policies?

Ursula Vogler: SB 375 focuses on growing population and job centers around existing transportation infrastructure. Of the 15% mandated reduction by 2035, about 9% will come from integrating transportation and land use, and 6% will come from the other climate initiatives, such as EVs. SB 375 addresses personal passenger vehicles. The 9% is based on MTC's current investments in transportation, which includes current county projects.

John Davies, FHWA: Quantifying demand management and eco-driving—on the demand management side, did you have a survey to make sure that all the trips going to those modes were additional and were not being usurped from transit?

Ang-Olsen [answered the question, but he did not use a microphone in the beginning]: We tried to the scale the level of the evaluation with the level of the grant.

Davies: Did the methodology have a way of tracking driving patterns over a longer period of time?

Vogler: Yes, that has been a concern of ours. Through the UC Davis program we did see some drop over time.

Ang-Olsen: We have not been looking at eco-driving for very long. It is difficult.

BREAKOUT SESSION 2

Institutionalizing Sustainable Practices Globally

ARTURO ARDILA-GOMEZ
Lead Transport Economist, World Bank, presiding

CREATIVE GROUP DECISION MAKING FOR SUSTAINABLE TRANSPORT DEVELOPMENT

Henrik Gudmundsson, Technical University of Denmark

- The SUSTAIN Research Project: Visions of National Sustainable Transport Planning (NSTP).
- NSTP. Systematic, knowledge-based efforts to integrate sustainable development principles, criteria, and goals in the design implementation, management, and regulation of nationally significant transport systems and services:
  - Integrates sustainability into existing systems.
  - Informed by the following ideas: sustainable development as a goal and a process, the sustainable mobility paradigm.
- Basic notions of sustainable development:
  - Meeting needs of the present without compromising the needs of the future.
  - Promoting an economically, socially, and environmentally sustainable future.
  - It is a process of change.
  - Reform institutions and social practices to ensure an environmentally sound and equitable development trajectory.
- Conventional versus sustainable mobility planning (David Banister, 2007):
  - Conventional transportation planning and engineering: focused on the physical infrastructure, economic evaluation.
  - Sustainable mobility: consider the social and environmental dimension, multicriteria analysis including environmental and social concerns; cost–benefit analysis does not dominate; involves affected stakeholders in decision preparation and assessment processes.
- Creative group processes as a systematic planning approach:
  - Systemic planning is based on the idea that can we cannot plan the world, because the world is complex; but there is more than one solution. Applies hard and soft methodologies.
  - Creative group processes is a bottom-up, context-sensitive, and open approach were solutions are based on interactions.
- Creativity is characterized by the ability to ask questions, see and interpret situations and problems in a new way, see and recognize alternative perspectives, recombine ends and means, and respond to new opportunities and risks.
- Five modes of inquiry in systemic planning: core performance (cost–benefit analysis, travel time savings), wider performance (things that are not as easily quantified, such as what we imagine for the region), fairness (consideration of potential conflicts), diversity (to ensure that things are not overlooked), and robustness (will the decision hold if assumptions change?).
- Composite methodology for assessment:
  - Attributes of alternatives are scored using pairwise comparisons under each

criterion (similar to analytic hierarchy process), and criteria are then given weights.

- Confirming validity and exploiting creativity:
  - Validity: Have all five modes of inquiry been given full attention? Have participants taken ownership of the outcome? Are the deliberation and decisions available to others?
  - Creativity: Revisit alternatives and solutions. Address cognitive biases.
- Findings and conclusions:
  - Sustainability is complex and involves multiple dimensions and perspectives.
  - Creative group processes allow bottom-up sustainability practices to be combined with top-down sustainability criteria.

DEVELOPING A NATIONAL TRANSPORTATION SUSTAINABILITY PLAN FOR NAMIBIA

Palesa Hekandjo and Taapopi Ithana, Roads Authority of Namibia

- Background on Namibia:
  - Located along the southern Atlantic coast of Africa, with a population of less than 2.3 million.
  - The economy is mainly based on natural resources, with a focus on mining, agriculture, fishing, and tourism.
  - There are two ports and two international airports.
- The Road Authority (RA) was created through road reform in 2000.
- RA worked with Texas A&M Transportation Institute to develop a Road Transportation Sustainability Plan from 2013 to 2014.
- Seven goals of the sustainability plan: improve road safety, enhance preservation of road infrastructure, promote capacity building and workforce development, increase funding for road transport, optimize the balance between access and mobility, preserve Namibia's environmental and ecological systems, and pursue new innovations and technologies.
- The goals have been incorporated into the RA Strategic Plan.

SUSTAINABILITY AS AN ORGANIZING PRINCIPLE FOR TRANSPORTATION AGENCIES

Gary McVoy, McVoy Associates

McVoy opened with a quote from Dr. W. Edwards Deming: "The obligation of any component is to contribute its best to the *system*, not to maximize its own production, profit, or sales." His presentation is based on the report available at http://onlinepubs.trb.org/onlinepubs /nchrp/nchrp_rpt_750v4.pdf.

- Sustainability:
  - Why? There's only one planet.
  - What? A triple bottom line comprised of people, planet, and profit.
- Transportation plays a role in governance and policy making, decision making, and enterprise management.

- Sustainability Maturity Model:
  - Level 0: Safe mobility. Building for the short-term, building no matter what is in the way.
  - Level 1: Compliant Transportation. Some laws exist, and they are complied with; top-down planning.
  - Level 2: Green transportation. Emphasizes environmental concerns.
  - Level 3: Sustainable Transportation. Considers economic, social, and environmental concerns. Favors partnerships between the public and private sector. The transportation agency is an infrastructure coordinator and regulator.
  - Level 4: Triple Bottom Line (TBL) Sustainability. Long-term sustainability focus, focused on multimodal mobility. The transportation agency is a transportation support steward. Ownership or control of the system depends on what is most sustainable.
  - A survey instrument is available for agencies to score themselves.
- Conclusions of the New York State DOT Maturity Model Pilot:
  - Progress is bound by external factors, such as budget, laws, staffing, and expectations.
  - Dialogues are important for providing more information than a survey.
- Goals and metrics should be SMART (Specific, Measurable, Attainable, Realistic, Timely) and HARD (Heartfelt, Animated, Required, Difficult).
- GreenLites. A tool that New York State DOT applies to all projects.
- Next Steps for the Checklist Systems provide more quantification, such as project and program results.
- U.S. DOT TIGER Program incorporates the TBL and puts a value on everything.
- TBL Valuation System currently bound by benefit–cost analysis conventions because economists and engineers are more comfortable with precision, but precision tends to trump accuracy.
- Next steps: sustainability should be used as an organizing principle.

SUSTAINABLE INFRASTRUCTURE: TRANSPORT IN LATIN AMERICA

Graham Watkins, Inter-American Development Bank

Watkins began by explaining that Inter-American Development Bank (IDB) is likely covering 5% of infrastructure costs in Latin America, in contrast to the 30% that Irigoyen estimated that banks were contributing.

- Latin America is highly urbanized and the population is growing dramatically; is vulnerable to natural disasters (earthquakes, hurricanes); and is a biodiversity superpower.
- Vision for infrastructure includes a shift from thinking of infrastructure as an asset to thinking of infrastructure as a service delivery vehicle.
- Addressing institutional needs is very important in Latin America. Once institutional needs are addressed, it is possible to address economic, social, and environmental issues.
- IDB initiatives include sustainable infrastructure, climate change action plan, emerging and sustainable cities initiative, biodiversity and ecosystems services program, and road safety strategy.

QUESTIONS AND ANSWERS

Following the presentations, Arturo Ardila-Gomez began the discussion. He is from Bogotá, which is known internationally for its BRT system. Since, 2003 no mayoral candidates have won on a sustainability agenda. All the winners have had a pro-car agenda. What is the role of politics in sustainability? Sustainable transport has not been able to win elections in Bogotá.

Guillermo (from the web): Decision making in group processes—as a decision maker you integrate different stakeholders, with varying interests. How do you appraise them? Who "cuts the pie" at the end? Who is responsible for the efficiency of the allocation of resources?

Gudmundsson: The decision-making process presented earlier does not supersede democratic processes. Elected politicians must "cut the pie." Even limited agreement around stakeholders can provide valuable information.

McVoy: Decisions are political decisions. We should push for valuation because everyone can understand the value of money, and valuation allows everyone to talk in a common language, which can better inform everyone.

Ardila-Gomez brought up the fact that McVoy expressed doubt that TBL sustainability could be used in political settings.

McVoy: Sometimes politics is not transparent.

Graham Watkins: The question is the crux of the problem. If you do not get the upstream planning right, then things can become dangerous. Public awareness is important to the functioning of the public sector. If the public rallies around sustainability, then organizations can more effectively implement sustainability. In smaller cities, people are closer to the politicians, and sometimes it is easier for change to begin there.

Venables: No amount of careful planning can cope with a wrongly framed political vanity project. All the advice in the world cannot direct a politician away from pressing forward with a flawed project. Framing projects in the context that has been discussed: How do you arrive at the best geographical and time boundary to make your decisions? How do the processes discussed balance adverse impacts and benefits?

Gudmundsson: Transportation infrastructure needs are insatiable. Bottlenecks will never go away, they will just move somewhere else. There are no limits to time and geography. One should let the impacts that one is interested in determine the limits to time and geography.

McVoy: The idea of "vanity projects" brings to mind the adage "sunlight is the best antiseptic." TBL analysis can use the universal metric of dollars to bound the problem in terms of time and geography, and address equity issues

Watkins: In Latin America, projects management can be decentralized. This decentralization can get projects done quicker, but it is not effective if the people who will be affected do not

approve. IDP does not fund projects that are in the wrong place (such as protected natural areas, or indigenous lands), but it is possible for such projects to receive funding from other sources, which can allow the project to go through.

Guillermo: Paraguagy does not have the resources to attract private funding. Much of their funding come from IDP, World Bank, etc. How can we get donors involved in projects (as oppose to making only demands)?

Unnamed speaker [maybe Giovanni Circella?]: How can sustainable practices be furthered in developing countries?

Gudmundsson: In Paraguay, it sounds like banks are part of the problem, not part of the solution. There is a lot of natural capital in Paraguay. Ecological economics puts value on environmental resources.

Taapopi Ithana: We cannot expect our leaders to consider sustainability. Common people have to be involved with the entire process.

McVoy: Analyzing costs and benefits is important to all proposals—whether a kitchen remodel or a new airport. There is a cost to gated communities. Why do people choose to live in them? What is the cost of avoiding gated communities?

Watkins: People in ministries need quicker and better projects. Banks are moving toward safeguard projects toward sustainable projects.

Online, read by the moderator [who did not use a microphone]: Will a focus on monetization weaken sustainability efforts?

George Panagakos, Technical University of Denmark: Does the culture of the country make a difference? Can the tools Gudmundsson discussed be applied outside of Denmark? In terms of Namibia, did you consider transit traffic from neighboring countries?

McVoy: The valuation approach can support both weak and strong sustainability. The valuation approach is a work in progress. In terms of different culture, it's fine that different cultures will have different values. The idea is to inform people and have a useful dialogue.

Palesa Hekandjo: We did consider Botswana and other land-locked countries, especially because of the ports, but we have not yet discussed Namibia's plans with the other countries.

Gudmundsson: Every place has to involve and work with stakeholders. Working with stakeholders can address conflict, rather than creating more conflict. Everyone needs to do it, though they might not be successful initially.

Unnamed speaker [the speaker did not use a microphone]: How can you use sustainability in elections?

Ardila-Gomez: Sustainable transport implies that part of the population changes their behavior. How do we do it?

Watkins: Information should come through social media. More funding could come out of the potential climate agreement in Paris, which could support sustainable development in developing countries.

McVoy: We need to bring more intelligence to the sustainability table. Most of the intelligence is involved in the economic system. To change behavior, prices should be changed.

Gudmundsson: To change behavior we need to change the incentive structure. For example, we could get rid of fossil fuel subsidies.

Ithana: This morning, Sperling mentioned that a chasm has to bridged to change behavior. People will be put in uncomfortable positions.

BREAKOUT SESSION 3

International Trade and Travel
Striving for Sustainability

TARA RAMANI
Texas A&M Transportation Institute, presiding

AN INTERACTIVE WEBSITE TO SHARE SUSTAINABILITY BEST PRACTICES

Kristin Lemaster, Changing Climate Consulting: Sustainable Aviation Guidance Alliance

- Background on airports: they are often mini-cities that must deal with security, water, and waste.
- SAGA (Sustainable Aviation Guidance Alliance) has a new website www.airportsustainability.org.
- SAGA is sustainability resource for the airport industry and beyond that started in 2008.
- Around 2006, 2007 sustainability became more of a concern to airports.
- SAGA published a guidebook and website in 2009 to facilitate airport sustainability plans.
- TRB took over the website in 2011, but they are currently trying to find a final owner for the website once it leaves TRB's hands.
- Website:
  - Library: people can come and look for records and can upload documents.
  - Designed for users of various levels of sustainability knowledge.
  - Users can also share what sustainability means to them. Emphasizes the point that stakeholder engagement is at the core of sustainability.
  - Search the heart of the website because it is a tool for sharing initiatives.
  - Data on the site can be added or edited.

POLICY EFFECTIVENESS OF ECONOMIC INCENTIVES IN THE AIR TRANSPORTATION SECTOR: COMPARATIVE ANALYSIS OF OFFSET PROGRAMS, EMISSION TAXES, AND EMISSION TRADE

Joel Zhengyi Shon, Tainan University of Technology

- Background:
  - How do we address the contributions of air travel to global emissions?
  - Around 2008–2010 some airlines began using voluntary emissions program on their own.
  - Per-mile, per-passenger GHG emissions are more for other modes than aircraft for trips over 2,000 mi. But who wants to take another mode for a trip over 2,000 mi?
  - All vehicles (including pure EVs) emit some CO_2 when they consume energy to move.

- Can we reduce GHG emission through economic incentives?
  - Probably yes, but it's hard in the aviation industry.
  - Emission taxes: airlines are charged for their emissions.
  - Emissions Trading Scheme: airlines buying the credit to emit.
  - Voluntary offset program: passengers can pay to offset their emissions through voluntary contributions.
  - However, these economic incentives often raise fares, and subsequently reduce travel demand.
- How much money to collect and from whom?
  - The externality should be internalized, and thus the polluter would pay, but who is the polluter?
  - The airline industry believes that the consumer (passenger), not the producer (airline) should pay, and thus the cost is often shifted to the consumer.
  - The fee or tax should be based on the amount emitted (based on flight type, flight distance, and load factor).
  - Pilots use different amounts of fuel for the same exact trips, so the numbers can never be exact because of this variation, therefore the money you are collecting as a tax is never exactly right.
- The cost of money collection:
  - Fixed versus variable taxes:
    - Fixed is the most simple, but not the fairest.
    - Variable taxes are based on the different routes, but technically, how can you actually vary the tax?
    - There are many variable that could affect taxes: the airlines can change aircraft, load factors can change.
    - Should taxes change based on changing prices of CO_2?
  - Offset collection:
    - Taxes can be collected with ticket sales, but airlines often charge a lot more than the market price.
- Cost of credit collection.
  - A complex system in which airlines trade to buy credit and shift the cost to consumers.
    - How consumers are charged: One-time charge? Charge by each transaction? Lump sum increase in fares? Based on per passenger mile? Should this vary by country?
- The willingness to pay.
  - From a survey of passengers traveling from Taiwan to Hong Kong, passengers were most willing to pay for a voluntary offset program, least willing to pay for a carbon tax (perhaps because they did not think the money would be put to its intended use), and the Emission Trade Scheme fell in the middle.
- Volunteer offset programs require money to go to a solution provider.
  - What is the administrative cost of having a solution provider (middle man) to collect a tax and put it toward something to reduce GHG?
  - If fares do not increase, demand will stay the same. Only those who can afford to, and are willing to pay, will participate in voluntary programs.
- Government expenditures from tax collection.

  - Taxes could lead to fair increases, which can cause shifts in demand.
  - Is it more important to lower demand or raise money to reduce GHG elsewhere?
  - Most governments do not have the capacity to carry out GHG reduction projects.
    - The overhead for government expenditures is very high; it is estimated that 30 cents of every $1 of tax collected will go toward what it is intended.
  - If we increase the emission tax should we reduce the consumption tax?
- Effectiveness of Emission Trade Scheme implementation.
  - Fares will likely increase and demand will be reduced as people switch to other modes.
  - Airlines will have incentives to switch to more-efficient aircraft, but only if it is financially feasible.
  - Airlines can bank their credits for future use.
  - Cap and trade issues: if the cap is not free, who gets the money? Also, where does the money go?
- Comparison of incentives:

	Voluntary Offset	**Emissions Tax**	**Emission Trade**
Fare increase	—	Yes	Yes
Demand decrease	—	Yes	Yes
Transaction cost	Low	Medium	High
Willingness to pay	High	Low	Medium
Policy effectiveness	Medium	Low	High
Accuracy of amount paid	Low	Medium	High
Fairness	Low	Low	Low

- Conclusions:
  - Further questions: Should income determine how much you pay? Should how much space you occupy determine how much you pay?
  - Future studies: incentive combinations, comparing willingness to pay among different countries
  - All private vehicles need to be a part of the emissions system.

SUPERGREEN: MAPPING SUSTAINABILITY AND EMISSIONS OF TRANS-EUROPEAN TRADE CORRIDORS

George Panagakos, Technical University of Denmark Transport

- The "Green Corridor":
  - A European concept of freight corridors, in which advanced technology and comodality are used to achieve energy efficiency and reduce environmental impact (defined in the 2007 Freight Transport Logistics Action Plan).
  - Comodality: optimal use of old transport modes, either alone or in combination.
  - Features:
    - Concentration of freight volumes over long distances,
    - Comodality and advanced technology,
    - Adequate trans-shipment facilities,
    - Green propulsion and eco-friendly fuels,

    - Possibility of demonstrating innovative transport solutions, and
    - Fair and nondiscriminatory access.
  - Benefits:
    - Mitigating congestion by shifting cargo off roads.
    - Creates positive externalities for road users.
    - It can be done through improving competitiveness of rail and waterborne transport, and consolidating cargo on certain corridors.
    - Economies of scale make it more advantageous to use alternative fuels.
    - Transportation networks in Europe are very fragmented. Green Corridors help with interoperability problems because international issues are dealt with during the development of the international corridors.
    - Enhanced cooperation. This is the greatest problem of modern logistics, and it is often due to lack of trust among participants in the market.
    - Comodality leads to optimized use of existing networks. Therefore, lower needs for additional funds for network expansion.
- The Super Green Project.
  - A project from 2010 to 2013 involving 22 partners from 13 countries, and lead by the National Technical University of Athens.
  - The objectives were to support the European Union's freight transport logistics action plan on green corridor issues, encourage comodality for sustainable solutions, benchmark corridors on key performance indicators, undertake networking activities between stakeholders, deliver policy recommendations, and support related research and development.
- Selection of corridors.
  - Criteria include a balanced network of modes and geography; also needed to include green segments and corridors with a lot of "greening" potential.
  - KPIs (key performance indicators):
    - Made a list and took it to stakeholders for feedback, and stakeholders said the list was too long.
    - It was difficult to limit indicators, so they asked the stakeholders to vote (they had to choose whether they could manage without, must have, or prefer not to have the various indicators).
    - The six final KPIs were cost, transport time, reliability, frequency of service, CO_2 emissions, and SO_x emissions. It was decided that KPIs should be chosen based on the objectives being pursued.
  - Initial methodology: decompose the corridor into a set of typical transport chains, calculate KPIs for each chain, aggregate chain to corridor-level KPIs, and aggregate corridor level KPIs to a single corridor indicator.
  - Benchmarking results: low speeds for road transport (probably because of delays in terminals), and high variance of intermodal transport attributes (due to the different characteristics of different segments).
    - In analyzing corridors using the KPIs, a range was produced. Some of the ranges had a very high variance. Aggregation did not work well because the sample sizes were too small.
  - Final methodology: disaggregate the corridor into typical transport chains according to transport market study, estimate the KPI values for each of these segments

using the transport market study, aggregate these values using weights and methods specified in the transport market study, and use the same sample to monitor performance in subsequent years (like a basket of goods and services used to calculate the Consumer Price Index, but for corridors).

- What are the issues in the EU infrastructure policy?
  - Missing links (especially crossing borders).
  - Disparity in the quality and availability of infrastructure (bottlenecks).
  - Infrastructure investments are needed to achieve GHG reduction targets.
  - Interoperability due to different operational rules and requirements by member states.
- New infrastructure policy adopted by the EU in 2013.
  - Comprehensive network (2050 implementation) reflects the relevant existing and planned infrastructure in member states, and involves updating and adjusting the current TEN-T.
  - Core network (2030 implementation) focused on cross-border missing links, key bottlenecks, and multimodal nodes.
- TEN-T core network corridors involve at least three transit modes, cross at least three EU states, cover the most important cross-border long-distance flows in the core network, and include at least one maritime port and its accesses.

- Green characteristics:
  - Comodal: adequate transshipment facilities, integrated logistics concepts.
  - Reliance on advanced technology: energy efficiency, use of alternative clean fuels.
  - Development and demonstration of environmentally friendly and innovative solutions.
  - Collaborative business models.
- A green corridor is efficient, but an efficient corridor is not necessarily clean.
- TEN-T core network corridors meet the criteria of green corridors.
- Conclusion: the methodology can measure a single corridor over time, but cannot be used to compare corridors. This is because each corridor has its own characteristics, e.g. crossing the Mediterranean Sea and crossing the Alps.
- Websites:
  - supergreenproject.eu and
  - www.grecor.eu.

QUESTIONS AND ANSWERS

Ramini began the question and answer session by naming some of the implications of the topics of aviation, trade, and logistics, such as online shopping, and world travel.

Joe Zietsman: What are the airlines' (including cargo shippers) responsibility to reduce emissions?

Joel Zhengyi Shon: Airlines are the producers, not the consumers. However, it is true that their product is not very environmentally friendly. The consumer could choose a greener airline, if

that exists. There are several types of pollution in aviation, including noise and GHGs. We asked airlines if they are willing to change their aircraft to be more environmentally friendly, but airlines say no, they will only change their aircraft when it makes sense financially. Environmental factors and updating their fleet is not airlines' first priority.

George Panagakos: Each plane has its own characteristics and airlines can make smarter decisions based on the specific route and what aircraft would be more efficient. A "single airspace" can optimize air travel. Currently, the global airspace is fragmented and each country sets their own guidelines on the corridors used. A single space can be designed so that air travel will be more efficient. As Shon discussed, financial, market-based measures are not as effective as people think. But, the price of fuel and the fuel consumption of airplanes can be incentives.

Kristen Lemaster: Airlines and manufacturers (such as Boeing) have very different motives and getting them to cooperate can be very difficult.

Roger Venables, CEEQUAL: Flying may be bad for the environment, but it may be more important to reflect on the purpose of the flight and whether the flight can be justified. If one travels for a social good, then that it is a good use of air travel. We are quite used to the idea of investing money to get return. Now we are looking at investing in carbon in order to get carbon returns. It might be helpful to think about how much someone is using in the context of other people giving up their carbon to support another person's travel. What is the greenest airport in the world?

Lemaster: SAGA is not evaluating airports. You should look up "carbon for carbon" in the SAGA database under social practices.

Question from the web: In the SAGA database, what practices are specific to airports, and could they be applicable to other modes? Is there more than one input on the cost data?

Lemaster: Less than 20% of practices are specific to airports. Airport-specific practices address runway design, taxiway design, air fuel design, and pavement design. The rest of the practices are multimodal and address topics such as buildings and stormwater.

For one practice there can be multiple case studies, but there can be only one data point for cost information. Users input the cost numbers, and they can be edited or commented on if you think that that answer is wrong. The cost ranges on the website are not very specific, and hopefully the broad ranges will help avoid strife among users.

Question from the web: The decision of where to locate the corridor will have a lot of benefits and costs. How do you decide the location?

Panagakos: Two sets of corridors were shown in the presentation. The first set was selected for SuperGreen. The corridors selected for SuperGreen do not have an effect on the real economy because they were only theoretically tested. The second set of corridors was the TEN-T corridors. Choosing the TEN-T corridors was a long process with multiple stakeholders.

Gudmundsson: Is there any comparison between long distances and last mile? There are great

efficiency differences between the two, as long-haul trips can be efficient in terms of CO_2, but local distribution can be inefficient.

Panagakos: Our methodology only deals with long-distance travel because for short distances there is no competition for trucks (trucks are the fastest for very short distances). How can the use of trucks for short distances be optimized? Smartly located urban distribution centers? Intermodal terminals outside of cities are within the scope of the project because they are the starting point for the long-distance trips.

BREAKOUT SESSION 4

Sustainable Transportation and Climate Change

RICH BALDAUF
Environmental Protection Agency, presiding

POTENTIAL FOR DIESEL BLACK CARBON FROM THE UNITED STATES AND EURASIA TO IMPACT ARCTIC SNOWMELT

Jennifer DeWinter, Sonoma Technology

The study presented was initially funded by the U.S. Forest Service to understand the impact of forest fires.

- Overview of emissions:
  - Since 1990, improvements to vehicles and fuel standards have led to reduced emissions from cars and trucks.
  - There have been important health benefits as exposure to $PM_{2.5}$, NO_x, and diesel particulate matter (DPM), which includes black carbon (BC).
- BC is a component of fine particle mass ($PM_{2.5}$), and smaller than 1 μm in diameter. It is formed during the incomplete combustion of fossil fuels, biofuels, and biomass
  - In 2005, 52% of U.S. BC emissions were from transportation, and 46% of U.S. mobile BC emissions were from on-road diesel.
- BC and health:
  - $PM_{2.5}$ is a criteria pollutant associated with negative respiratory and cardiovascular effects, and premature death.
  - BC particles represent a fraction of primary and secondary $PM_{2.5}$ (the amount depends on the emission source).
  - The EPA lists DPM as an air toxin, and health studies indicate that it is the greatest contributor to cancer risk. BC is 30% to 50% of DPM.
- BC and climate:
  - Atmospheric BC reduces sunlight because it is light-absorbing, and causes warming.
  - BC deposits on snow and ice accelerate warming.
  - It is shorter lived than CO_2, and can be used to reduce climate change in the short term.
- Focus of research: quantifying impact of BC on the Arctic.
  - What meteorological patterns are conducive to transporting emissions to the Arctic?
  - How do location, timing, and emission source height affect transport?
- Methods: climatological trajectory analysis from January 1979 to December 2009.
- Results: transport potential varies by emissions source height.
  - Lofting at the source increases the likelihood that trajectories reach the Arctic.
  - Transport potential increases over time.
  - Emission from locations where transport is greater may be more likely to impact the Arctic.

  - In California and Texas $PM_{2.5}$ emissions are high, but there is not much transport potential to the Arctic.
- Future impacts:
  - $PM_{2.5}$ exhaust emissions are predicted to decrease sharply from 2010 to 2020, and thus reductions in BC are expected.
  - The locations of the reductions are important for reducing Arctic impacts.
- Conclusions:
  - Transport of BC varies by latitude, day, season, and year.
  - Emission reductions will have climate cobenefits.
  - BC emissions from transportation are expected to decrease in the United States.

Questions and Answers

Unnamed speaker: What do you think are the transport potentials in other regions?

Jennifer DeWinter: We did similar work for Europe and Asia. There was greater transport from Europe and Asia to the Arctic, and transport is greater from Russia to Western Europe. There are similar patterns of particle transport, but also some differences.

Rob Graff, Delaware Valley Regional Planning Commission: DVRPC publishes a regional energy use and GHG emissions inventory for the nine counties of the Philadelphia region, could you provide guidance for including BC in the next GHG inventory?

DeWinter: A metropolitan planning organization-level inventory is not my background, but I would be happy to follow-up.

Graff: How can one use the transport potential by height information to project information for vehicles, where the height of emissions is not close to 500 m above ground level?

DeWinter: Depending on the place, 500 m could be a proxy for surface-level emissions for cars and trucks, and the results presented could be relevant for those locations. Results of studies in Los Angeles indicate that after new mixing occurs, 1,000 m is possible for those surface emissions. Fire creates buoyancy, so the levels we looked at were much higher.

DAILY TRAVEL AND CO_2 EMISSIONS FROM PASSENGER TRANSPORT: A COMPARISON OF GERMANY AND THE UNITED STATES

Kyle Lukacs and Ralph Buehler, Virginia Polytechnic Institute

- Why Germany and the United States?
  - Similarities are: western democracies, federal systems of government, local self-government, strong economies, high standards of living, large car manufacturing industries, high levels of car ownership, most adults have driver licenses, extensive road networks, and tremendous urban and suburban (re)development since World War II.
- Trends in CO_2 Emissions from Passenger Transport in Germany and the United States:
  - Ground passenger transport total CO_2 equivalent decreased by 15% in Germany

and increased by 12% in the United States from 1990–2010.

– Ground passenger transport CO_2 equivalent per capita decreased by 17% in Germany and decreased by 9% in the United States.

– Ground passenger transport CO_2 equivalent per passenger kilometer decreased by 20% in Germany and decreased by 3% in the United States.

– Ground passenger transport CO_2 equivalent per constant $1,000 gross domestic product (GDP) decreased by 36% in Germany and decreased by 31% in the United States.

- Fuel efficiency and CO_2 emission standards:
  – U.S. CAFÉ. The world's first emission standards were introduced in 1975. Originally they were effective, but subsequently the standards were not raised. The standards for light trucks are low, and they have become increasingly popular, which has not had a positive effect on U.S. emissions.
  – In Germany, there are no fuel efficiency standards at the national level. The EU enforces fuel efficiency standards, and is aiming for 60.6 mpg by 2020.
  – How to design and update standards? The United States uses track width and the EU uses weight.
  – The German car and light truck fleet is 55% more fuel efficient (35 mpg versus 23 mpg).
- Incentivizing less polluting cars and fuels:
  – Germany: annual vehicle registration fees for new cars include a small share based on CO_2 emissions, though EVs are exempt for 5 years (about €2 per gram of CO_2 emissions above a certain threshold). The newer the car, the lower the threshold. The few may be too small to have the intended effect.
  – United States: incentives (tax credits) and privileges for certain cars (up to $7,500 for EVs).
  – The Cash for Clunkers programs in the United States and Germany help get older, less fuel-efficient cars off the roads.
    - United States: $3,500 to $4,500 per car, the new cars had to have a mpg of 22, and the old cars had to have a mpg under 18.
    - Germany: €2,500 for cars older than 9 years.
    - Pro: new cars on average produce 20% fewer emissions.
    - Con: what happens to the older car? It could also be useful to consider the total life cycle of the car.
- Travel behavior:
  – About 86% of trips in the United States occur by car versus 58% in Germany. Germans are 4.5 times more likely to use public transportation, 10 times more likely to ride a bicycle, and 2.5 times more likely to walk than Americans.
  – Americans drive almost twice as many kilometers per year (21,700 versus 11,000).
  – The average trip distance is longer in the United States (9.8 mi versus 7 mi), but that does not fully explain the different driving rates.
    - A similar share of all trips is less than 1 mi (32% in Germany and 27% in the United States). Americans drive for 67% of these short trips, whereas Germans drive for 27%.
  – Americans living at high densities make a similar share of trips by car as Germans at lower densities.
  – Public policies at federal, state, and local levels help explain differences in car use

and CO_2 emissions.

- 2009 National Household Travel Survey (United States) and 2008 German Household Survey:
  - CO_2 emissions were higher in the United States, except for households without a car.
  - U.S. households with one car produced eight times more emissions than the equivalent German household.
  - Employed U.S. workers produced 5.6 kg more than employed Germans
  - Higher-income people tend to have higher emissions, but the highest income Germans had lower emissions than the lowest-income Americans.
  - Land use: the densest places in the United States have greater emissions than the least-dense places in Germany.
- Policies that restrict car use and make it more expensive:
  - Gasoline taxes:
    - German taxes are eight times higher.
    - Taxes account for 62% of the price in Germany, and 18% of the price in the United States.
    - The price has been increasing much quicker in Germany.
    - The U.S. gas tax has not been increased since 2003.
    - Higher gas taxes do not lead to higher household transportation costs; in Germany, the average household expenditure on transportation is 15%, but in the United States the average household expenditure on transportation is 17% (which is about $2,500 more).
- Policies that promote public transport as a viable alternative to driving for daily travel:
  - Quantity and quality of service: vehicle-kilometers of service per person is three times higher in Germany: 60 vehicle-kilometers per person per year in Germany, versus 20 in the United States; 88% of Germans live within a kilometer of a public transit stop, whereas 43% of Americans do; Germans make 6.5 more public transport trips than Americans.
  - Regionwide integration with other transportation modes, regional fare coordination.
  - Discounts on annual passes.
  - Real-time information on transit.
  - Traffic prioritization.
  - In the United States, most public transportation is concentrated in large cities with commuter rail. Suburban areas are focused on commute-oriented public transport (essentially runs during the weekday commute).
- Policies that promote cycling and walking as a viable alternative to driving for daily travel:
  - In Germany, more federal funds have been spent on nonmotorized transportation.
  - Car-free zones.
  - Traffic calming. Germany generally avoided having limited-access highways in cities and downtowns. In the United States, the federal government has subsidized highways, and so they are common. In Germany, more than 70% of major cities have traffic-calmed streets, with speeds of about 19 mph, and walking speeds of about 4 mph.
  - Pedestrian facilities: in the United States, many suburban areas lack sidewalks.
  - Bikeway networks.

  - Traffic education. In Germany, driver licenses classes emphasize pedestrian and cyclist rights. The fatality rate per kilometer cycled or walked is four to five times higher in the United States than in Germany.
  - Sales tax for new cars.
  - Road revenues and expenditures.
  - Traffic calming and speed limits in urban areas.
  - Roadway and parking supply in urban areas.
    - In the United States, 95% of trips are subsidized by free parking.
- Conclusion:
  - CO_2 emissions from transport are higher in the United States than in Germany, even when controlling for population, economic activity, and travel distance.
  - Between 1990 and 2010, Germany reduced CO_2 emissions from ground passenger transportation.
  - Efficiency standards can help boost fuel efficiency of new vehicles, but it is difficult to adapt standards to changing technology, politics, and societal preferences.
  - Incentives for the purchase of more fuel-efficient cars (tax credit, reduced annual fees) can increases demand for fuel-efficient vehicles, but the programs are often too small and incentives are often too little.
  - Germany has been able to achieve higher fuel economy and greater emission reductions without fuel economy or emission standards
  - Technological improvements are prone to the potential rebound effects of heavier vehicles, large engines, and greater car travel demand.
  - Policies focused on technological improvements can only be part of a policy package geared at reducing CO_2 emissions from transport.
  - Recent trends in travel demand and travel preferences among young adults may provide an opportunity for policies that promote walking, cycling, and public transport.
  - Data from Germany indicates that public policies can reduce car travel demand while making walking, cycling, and public transport more attractive.

Questions and Answers

Giovanni Circella, UC Davis: What is playing a larger role in changes in travel behavior?

Kyle Lukacs: The changing generational landscape plays a role. Germany is a denser than the United States. If cities are built more densely, then there are likely to be changes in travel behavior. Regional coordination is also important for public transport.

Todd Litman, Victoria Transport Policy Institute: A lot of the analysis you have done would be interesting at the regional level, rather than the national level. Did you do some of this analysis for individual cities? Is there data available to do that type of analysis?

Lukacs: Ralph Buehler is the research lead, and he is in Austria right now, so I cannot fully address that question. I agree it would be interesting to look at data at the city and regional level.

ASSESSING HOUSEHOLD TRAVEL ENERGY CONSUMPTION AND CARBON EMISSIONS BASED ON URBAN FORM: A CASE OF JINAN, CHINA

Yang Jiang, Sustainable Transportation Center, Tsinghua University

- Motivation for the study: car-oriented neighborhood and street design, the inapplicability of Western models in China, a lack of empirical evidence.
  - China is urbanizing much more quickly than the United States.
- Approach: people > urban form> travel activity> transport energy/emission.
  - Space modules accommodate the expected growth of population and jobs using neighborhood/street types.
  - Behavior modules look at car purchasing and trip making, which is influenced by urban form.
  - Energy–emissions modules transform household travel activities into energy consumption and carbon emissions.
- Jinan case study:
  - Using the Chinese version of Google Streetview, researchers recorded street features (trees, crosswalks, etc.).
  - Housing types: traditional, enclave, grid, superblock.
  - Empirical analysis:
    - Density [e.g., floor area ratio (FAR)];
    - Diversity (e.g., number of points of interest);
    - Design (e.g., distance between entrances); and
    - Location (e.g., on BRT corridor),
  - Results: there is a negative relationship between building coverage vehicle kilometers traveled, but FAR is not significantly correlated; where there is a greater mix of building types people drive less. People-oriented urban design can lower emissions and energy use.

Questions and Answers

Unnamed speaker: Have you bridged the gap between planning and transportation professionals?

Yang Jiang: Traffic engineers are typically focused on building roads. A lot of transportation professionals in China are not familiar with urban design. This research was important because it quantified street features. It is a step in the right direction to quantify the differences between neighborhoods and how they affect energy use and travel behavior.

SUSTAINABILITY OF DOT ASSETS TO CLIMATE CHANGE EFFECTS

Robert Chamberlin, RSG, Inc.

Chamberlin's research is with the Ohio DOT.

- Motivation for the study: the likely effects of climate change on infrastructure, transportation, and other areas in the Midwest. Coastal states are concerned about sea-level rise,

but climate change will also affect interior states.

- Anticipated climate change effects:
  - Gradual: increasing average temperatures, longer duration of drought, reduced lake water levels.
  - Event-driven: greater frequency of heavy precipitation events.
- Ohio is focused on the increasing variability of precipitation and stream flows, and focused on stormwater management, bridges, and highways.
- FHWA model creates a vulnerability score by weighing the scores for exposure (how exposed is the asset to a climate stressor), sensitivity (how severely will the asset be damaged), and adaptive capacity (ability of an asset to cope with damage).
  - The model should be build with the experts (engineers, hydrologists, planners).
  - Data sources: exposure (e.g., previous flooding issues), sensitivity (e.g., channel condition), adaptive capacity (e.g., distance from sites of critical importance).
  - Each asset, such as a bridge, as a vulnerability score.

Questions and Answers

Unnamed speaker: How is service continuity being factored into what you're doing? Are you defending highly vulnerable bridges or bridges on core routes? In Chile, they are underbuilding bridges that are not on the core network.

Robert Chamberlin: Service continuity underlies a lot of this. The vulnerability model considers whether an asset is part of the strategic transportation system. The system in Chile is interesting because it is interesting to consider a system failure that will not be disastrous.

Question from the web: Can you talk about the political context of climate change in Ohio (practical versus shying away)?

Chamberlin: It's important that one of the departments within the Ohio DOT initiated a study like this. Their management is interested in vulnerability to climate change. DOTs are focused on serving their customers *now*. It does seem hard to get their attention for something that could be 25 years or farther in the future. It looks like a critical mass is being built and that people think that climate change is an issue that is not going to go away.

Rich Baldauf: TRB does have a task force and a subcommittee on climate change.

BREAKOUT SESSION 5

Measuring Sustainability

GIOVANNI CIRCELLA
UC Davis/Georgia Institute of Technology, presiding

INVEST SUSTAINABILITY TOOL

Frank Holzmann, Texas DOT

Holzmann spoke about the use of FHWA's INVEST program in the Harbor Bridge project.

- INVEST (Infrastructure Voluntary Evaluation Sustainability Tool): a web-based tool to help transportation agencies integrate sustainability into their programs and projects.
- Three modules with a scorecard attached to each module for evaluating the full life cycle of transportation services:
  - Systems planning: evaluates agency's systemwide transportation planning and programming (such as statewide long-range transportation plans).
  - Project development: early planning, alternatives analysis, and construction.
  - Operations and maintenance: applicable to agency's internal and system operations, related to asset management.
- Harbor Bridge, Corpus Christi, Texas:
  - A steel span bridge built in the 1960s is being replaced with a cable stay bridge; once constructed it will be the longest cable stay bridge in the United States.
  - Texas DOT put out a request for a design–build project, with a 25-year maintenance contract.
- Use of INVEST:
  - July 2014: the project developer teams attended an INVEST workshop in Corpus Christi.
  - August 2014: a pre-scoring workshop was held.
  - The request for proposals and technical provisions were updated to be consistent with INVEST. The proposal stated that developers had to explain how they would obtain a platinum INVEST rating.
  - Life-cycle cost analysis, habitat restoration, freight mobility to allow for larger ships, and reduced energy emissions in pavement materials were some of the sustainability components. The contractor was required to have a sustainability manager to ensure that they include what they promised.
  - April 2015: the contract was conditionally awarded to Flatiron/Dragados JV who say they will meet a platinum rating in operations and maintenance.
- Sustainable elements:
  - Bridge lighting fixtures will be LED, solar-powered path lighting, and energy-generating wind sculpture near plaza.
  - High-strength, low-permeability concrete mix; re-use concrete from demolished bridge in landscaping.

ASPHALT PAVING, SAN JUAN NEPOMUCENO TO ROUTE 6, AND USING INVEST

Guillermo González Lopez, Ministry of Communications and Public Works, Paraguay

- The project dealt with paving a 97 km dirt secondary road that traveled along wildlife areas, rural communities, and indigenous communities.
- The Inter-American Development Bank suggested that INVEST be applied to the paving project.
- The road will incorporate wildlife crossings.
- Under INVEST, the project scored 32, which is a little below bronze.
- Next, INVEST will applied to the design stage, and it will need to be adapted to the reality and needs of Paraguay.

THE UNITED KINGDOM'S CEEQUAL SUSTAINABILITY TOOL IN ACTION

Roger Venables, CEEQUAL

- M-25, London's equivalent of the beltway (background of first slide), where three-lane motorways were turned into four-lane motorways without moving the road boundary. The northwest segment of M-25 was assessed in one of the first applications of CEEQUAL.
- CEEQUAL: sustainability assessment, rating, and awards scheme for civil engineering, infrastructure, landscaping, and works in public spaces.
- BREEAM: U.K. equivalent of LEED.
- CEEQUAL has become an influencing tool, and is now used internationally.
- How it works: there is a team-based self-assessment, points are only awarded for evidence, and the assessment is independently verified.
  - CEEQUAL assesses what is built and how it is built. Projects are not assessed on things that are not present.
  - There is no operations–in-use assessment.
- CEEQUAL considers avoidance of adverse impacts, reductions, mitigations, positive impacts, environmentally beneficial features, stakeholder involvement, resource efficiency, and legal compliance.
- The steps are consider–assess, plan, implement, and monitor–perform.
- The methodology covers: project strategy (how is the project contributing to the communities it serves?), project management, people and communities, land use and landscapes, historic environment, ecology and biodiversity, water environment, physical resources, and transportation.
  - Sustainability considers equity and the environment
- Benefits (based on feedback): helped stretch the sustainable performance of the project, aided the measurement and review of processes to ensure continual improvement, provided third party confirmation of sustainable practices, the collaborative approach ensures input from all parties.
  - Summary of benefits:
    - Team building;
    - Internal benchmarking— positive reinforcement, business improvement, innovation, improved project management;
    - Reputation and competitiveness;

    - Proactive management of sustainability aspects—identifying current performance, setting improvement plans, delivery of objectives and targets, identifying areas for improvement, and demonstrating continual improvement; and
    - Resource efficiency and cost savings.
- For the forth replacement project in Scotland, the bridge and the roads were evaluated separately and then the scores were aggregated.
- Actions that improve performance and save money—measuring the costs associated with the whole life of a project and its components, waste minimization, reducing energy consumption, reducing water consumption, minimizing complaints, minimizing costs of environmental incidents, and minimizing costs of dealing with protesters.
- CEEQUAL is established (in operation for 12 years) and recognizable (some people mention on their business card that they are "CEEQUAL-driven").
- Envision is a sustainable infrastructure rating system in the United States.

SUSTAINABLE TRANSPORTATION PERFORMANCE EVALUATION DATA NEEDS

Todd Litman, Victoria Transport Policy Institute

- Transportation professionals need data.
- What kind of information do we need: demographics, income, and employment; vehicle ownership; vehicle operating costs and fares; road and parking fees; freight transport demands; travel conditions; land use development; new technologies; consumer preferences; safety and health impacts; and environmental impacts.
- Data (also called statistics): specific information reported without context, such as traffic speeds.
- Information: organized and comparable data suitable for research, such as a statistical analysis of the relationship between VMT, traffic speeds, and traffic fatalities.
- Knowledge: abstract, organized, and transferable, suitable for decision making, such as a functional model that predict how specific transport policy and planning decisions will affect traffic accident risk.
- Wisdom: the ability to understand and apply knowledge, it considers context and values, such as a decision maker determining what planning and policy decisions are optimal, balancing accident risk against other planning objectives, and reflecting a community's needs and values.
- Quality data and analysis are essential for good decision making.
- Data types:
    - Inputs: vehicle ownership, road supply, and design; public transit supply and service quality; urban design (density, mix); and government expenditures.
    - Outputs: vehicle travel; walking, cycling, and public transit travel; mode share; fuel and energy consumption; and consumer expenditures.
    - Outcomes: accessibility (people's ability to reach desired services and activities); affordability (portion of household budgets devoted to transportation); per-capita government expenditures; health and death rates; and portion of land used for transport facilities.
- Quality data:
    - Accuracy: statistic collection methods must be accurate.

  - Transparency: statistic collection methods must be transparent.
  - Comprehensive: the range of statistics should allow for various types of analysis.
  - Frequency: data should be collected regularly.
  - Consistency: the statistics, definitions, and collection methodologies should be consistent.
  - Availability: statistics should be available to users.
- Types of data sets:
  - Supply: roads (supply and quality, such as congestion delay); sidewalks and paths (supply and condition); railroads (supply and quality); transit service (supply and quality); airports, ports, and vehicle ownership (type).
  - Activity: vehicle travel (by vehicle type); personal vehicle travel (by trip type, demographics, location); nonmotorized travel activity (by distance and time); mode split (by trip type, demographics, location); and freight transport (by mode, type, location).
  - Economics: fuel prices, public transportation fares, government expenditures on transport facilities and services, and consumer expenditures on vehicles and transport services.
  - Impacts: crashes and casualties, energy consumption, air and noise pollution emissions, and land use factors (land devoted to transport facilities, density, mix).
- Existing data sources:
  - International: International Road Federation, Millennium Cities and Mobility in Cities Database, Earth Trends Searchable Database, OECD Transport Statistics, and World Bank.
  - Europe: European Union Energy and Transport in Figures, European Commission, European Conference of Ministers of Transport, European Environment Agency, and Transport Statistics Great Britain.
  - North America: Bureau of Transportation Statistics, Highway Statistics, Census Bureau, National Household Travel Survey, Department of Energy, Statistics Canada, and Transport Canada.
  - It's difficult to integrate data from around the world because different definitions (e.g., vehicle type), categories (e.g., demographics), and metrics are used.
- Sustainable planning: sustainability emphasizes the integrated nature of human activities, and thus planning needs to be coordinated among different sectors, jurisdictions, and groups.
  - Economic: efficient mobility, local economic development, and operational efficiency.
  - Environmental: pollution reduction, climate change emissions, resource conservation, open-space preservation, and biodiversity protection.
  - Social: social equity, human safety and health, affordability, community cohesion, and cultural preservation.
- Data availability:
  - Generally available: transport facility supply, vehicle supply, public transport supply, motor vehicle traffic conditions, crashes, and pollution emissions.
  - Often unavailable: parking facility supply, nonmotorized transport conditions and activity, total transport expenditures, land use factors, disaggregated crash rates, detailed pollution emissions, and economic impact factors.
- Fun facts:

  - U.S. vehicle travel grew steadily during the 20th century, but stopped around 2003 because motor vehicle saturation, wealth effects, aging population, rising fuel prices, increased urbanization, increased traffic and parking congestion, rising roadway construction costs and declining economic return from increased roadway capacity, and environmental and health concerns.
  - The United States has about twice the annual passenger vehicle travel as Western European countries.
  - Reducing vehicle travel may reduce traffic fatalities.
  - In comparison to other OECD countries, the United States has the highest traffic fatality rate and highest annual vehicle kilometers per capita.
  - Per-capita vehicle travel tends to increase with incomes and economic productivity.
  - In affluent countries, per-capita vehicle travel tends to decline with increased productivity.
- What is most needed: statistics on nonmotorized travel and disaggregated data on parking supply
- Data problems*:* statistics are often incomplete; inadequate methods or sample size; transportation decision making is skewed in favor of easy-to-measure impacts; statistics are incompatible between agencies, jurisdictions, and time periods; statistics are often limited to a specific audience, or they are in a difficult format; and independent review and reporting is rare.
- One of Litman's sustainability definitions: planning that is not biased in favor of easy-to-measure impacts.
- U.S. and Canadian federal policy decisions may threaten data collection: reduction of the long-form Census, lack of coordination between jurisdictions and sectors, and lack of appreciation of data by decision makers
- If we spend more on data collection, then we can create a more-efficient transportation system.
- TRB and other U.S.-based groups need to be involved in the Global Transport Intelligence Initiative.

Questions and Answers

Giovanni Circella: This session provided information from different geographic regions, and discussed similar problems, but everyone had a unique perspective. CEEQUAL and INVEST are voluntary sustainability assessment tools. How can such tools go beyond rating a project, and can provide more sustainability assistance?

Frank Holzmann: I think [INVEST] does drive the projects. INVEST enabled the developer to incorporate a lot of elements of sustainability. The developer went beyond the rating. The costs associated with a more-sustainable project were insignificant, rather, choices were more significant. The tool forced the developers to find different ways of doing things, and some of the options had a cost savings benefit.

Guillermo González Lopez: In Paraguay, our INVEST score was limited by the technologies available to us.

Roger Venables: CEEQUAL has lots of inputs. Once a team has committed to a CEEQUAL assessment, the team is interested in scoring well. Oftentimes people save money when they choose the more sustainable option. Project managers can approach the CEEQUAL rubric by first considering when they can start considering the issue, and when they might expect to get the evidence of meeting the requirement. At the design stage, teams can set higher sustainability goals for themselves. At the contractor level, people may use CEEQUAl to focus on waste minimization. Responsible sourcing (the upstream environmental and social aspects of materials), such as local goods rather than goods acquired from far away, is an element of CEEQUAL that many people do not consider until they look at the rating system.

Circella: It's important that costs were lower when people chose the more sustainable option.

Venables: The more sustainable option does not always cost less, but if one weighs the costs and benefits, it may be worthwhile.

Todd Litman: Good planning is like a great sports team, where every action anticipates the next step. Good planning that anticipates the next step is expensive. But, bad planning is even more expensive. It is an order of magnitude cheaper to make a change before you start construction, than it is to make changes after construction begins. Life-cycle cost analysis and environmental and social impacts, can be used to argue for better planning.

Circella: Todd [Litman], your presentation showed a slide in which high VMT were correlated with a higher GDP. Could you explain the correlation between VMT and GDP?

Litman: I presented a more detailed version of that slide at a TRB conference last year on Transportation and Economic Development. It is from a paper on the VMT and GDP paradox. Sustainable transportation requires a paradigm shift. People generally think more is better (more travel, more vehicle ownership, etc.), and therefore expanding the transportation system achieves economic development. The new paradigm is focused on achieving efficiency. Policies that increase transportation efficiencies may reduce automobile travel and are key to economic development. It allows us to rethink our fundamental goals. We are no longer assuming that more volume is better. We are saying that too much is as harmful as too little.

Unnamed speaker: What were the barriers in your particular contexts to getting good data?

Holzmann: In a design–build process you never are quite sure what the developer will come up with.

Lopez: We did not have much data. In Paraguay, the 2012 census has not yet been published. We rely on the IDB to get consultants to gather data

Venables: Not all evidence in CEEQUAL is necessarily data. Data that a team is already gathering can be used as evidence in a CEEQUAL assessment. CEEQUAL will be adding more metric-related questions. You can only compare things with the same baselines.

Yannick Cornet: I have studied sustainability assessment tools. In the INVEST tool there is a

planning module, in CEEQUAL, people have to decide on the right infrastructure. How can the tools be used to determine if projects are the right projects to ensure sustainability?

Venables: CEEQUAL's primary connection with planning is under the Project Strategy section. The Project Strategy section considers the attributes of the project in terms of economic impacts and benefits, social impacts and benefits, and environmental impacts and benefits. CEEQUAL also asks if the project will help the community that it serves to live more sustainably.

Circella asked Litman to answer Cornet's question in person after the session because there was no more time.

Jonathan Fogg, from the web: Does INVEST account for bicycle activity?

Holzmann: Yes, in the planning component.

Gary McVoy: The contrast between Texas and Paraguay is interesting. We want to encourage people to do things that are important and easy. In terms of the rating systems, they should move beyond "yes or no," and should be based on a scale. The results of the sustainability tools need to be important.

Holzmann: The INVEST tool helped people think outside the box. Doing things a different way was not necessarily more expensive.

Venables: Yes or no questions are very carefully chosen. In some cases, you have to implement the entire process otherwise it is not worth doing.

BREAKOUT SESSION 6

Envisioning Sustainable Transport of the Future

ANTOINETTE QUAGLIATA
Federal Transit Administration, presiding

ROLE OF ZERO-EMISSION VEHICLE MANDATES IN THE TRANSITION TO SUSTAINABLE ENERGY FOR MOTOR VEHICLES

David Greene, University of Tennessee

In the opening remarks, Sperling said that climate change is an all-encompassing issue, in that it is an all-encompassing issue of sustainability. I will focus on the switch from high-carbon to low-carbon energy. Worldwide, and in the United States, about 95% of transportation energy comes from fossil petroleum.

- According to the Global Energy Assessment, sustainability requires an energy transition that poses a novel challenge for public policy, including immediate action, and the phasing out of conventional oil. This goes beyond internalizing externalities.
- Energy efficiency is the primary strategy for reducing GHG emissions from transportation, but tripling mpg will not be enough.
- An 80% reduction from 2005 GHG emissions for light-duty vehicles by 2050 will require a transition to zero-tailpipe emission (EVs).
  - In this scenario, a lot of biofuel is used, and it is drop-in biofuel, which is chemically gasoline, but made from biomass.
  - It is probably most important to use biofuels in heavy trucks and aircraft.
- We need vehicles with nearly-zero life-cycle GHG emissions to reach our goals.
  - Hyundai is selling a hydrogen fuel cell vehicle; Toyota will be selling one next year.
  - $58,000 is too much for a fuel efficient mid-size car, it will not be able to take over the marketplace.
  - We need economies of scale and more advanced technology.
  - Barriers include a lack of refueling infrastructure, resistance to novel technology, and limited choices.
  - There are long time constants for change, thus policies must begin now.
- Technological advances (from NRC's *Transitions to Alternative Vehicles and Fuels*):
  - Reducing vehicles' power requirements by reducing mass, aerodynamic drag, and rolling resistance, will make EVs cheaper than internal combustion engines after 2040.
  - In the long run, battery cell and fuel cell vehicles could be cheaper than internal combustion engines because the powertrain will be smaller because of the more efficient design of the vehicle.
- Cost–benefits of the transition for light-duty vehicles (from NRC's *Transitions to Alternative Vehicles and Fuels*): estimated benefits exceeded costs by an order of magnitude.
- Section 177 of the Clean Air Act authorizes states to choose to adopt California's emission standards in lieu of federal requirements. States are not required to obtain EPA

approval before adopting California's standards. The 15 states that have done so are "Section 177 States."

- Zero-emission vehicle standards are more complicated than CAFE standards (and based on what was said yesterday not a lot of people understand CAFE standards).
- Assumed major policy changes of a no zero-emission vehicles scenario:
  - GHG emissions–fuel economy standards would be tightened, and would reach 75 mpg by 2050, and manufacturers would offer "feebate-like" vehicle pricing.
  - The motor fuel tax would be converted to an energy tax, which would be indexed to the average mpg of all vehicles in use and inflation, and would be $1.50/gal by 2050.
  - Federal and state subsidies for alternative fuel vehicles end after 2015.
  - 23 billon gallons of low-GHG cellulosic ("drop in") biofuel in 2050.
  - Assume technological progress.
  - Without zero-emission vehicles or incentives for alternative vehicles and fuels after 2015, battery EVs and plug-in hybrid EV sales die out, but battery EV sales recover after 2040. No fuel cell vehicles are sold.
- Zero-emission vehicle scenario:
  - California and the Section 177 States assume a greater initial burden and provide spillover benefits to the rest of the United States. The rest of the United States adopts California's policies 5 years later.
  - Expected excess costs (subsidies) will be small relative to expected benefits. It will be a challenge to get through the early transition. It is fairly certain that money will be lost until 2025. Immediate GHG savings are not likely.
- Accomplishing an energy transition for the public good is a new public policy problem.
  - It will take decades. The difference between social and private discount rates will be critical.
  - Technological progress is required, but is inherently uncertain.
  - Not all the social costs are externalities (e.g., monopoly power in the world oil market).
  - Other important market inefficiencies (e.g., energy paradox).
  - The transition creates external benefits that are difficult for private agents to capture.
  - External benefits and positive feedback such as scale economies and learning by doing are powerful and create tipping points.

Questions and Answers

Henrik Gudmundsson: Could you elaborate on the slides showing the benefits and costs associated with transitioning to electric drive vehicles, particularly, petroleum savings?

David Greene: (Slide 11) the graphs comparing the early and later adopters of electric drive vehicles are similar, but the air quality benefits are smaller for the early-adopting states. The consumer surplus benefit is surprisingly large. You can have an internal combustion engine, but you can also have a hybrid, or a battery electric, at a cheaper price. In the United States, there are benefits to reducing our petroleum consumption. For instance, the economy is less vulnerable to price shocks. Literature indicates that price shocks in the oil market decrease GDP. Also, there is

evidence that the monopoly power of OPEC keeps the price higher that it would be in a competitive market. If a large consumer like the United States reduces consumption, the world price of oil will fall a little bit, and that reduction in price is a benefit. In the graphs, the petroleum benefit is based on the benefit of the monopoly, greater oil security, and the reduced impacts of price shocks. National defense and military costs are not reflected in the graphs. If the United States is producing more oil and its imports shrink, then the vulnerability to price shocks does not change, but the benefit associated with the OPEC monopoly does change. U.S. producers will receive the monopoly benefit.

Unnamed speaker: In the scenario with no zero-emissions vehicle mandate, there were no additional EV charging stations or hydrogen fueling stations. Also, how can transportation agencies facilitate the transition?

Greene: Yes, after 2015 there are no additional EV charging stations or hydrogen fueling stations in the no-zero emission vehicle mandate scenario. There are lots of issues related to codes, safety, and standards that are associated with zero-emission vehicles that transportation agencies can be involved with. In the real world, not in the model, state and local governments provide incentives for zero-emission vehicles, such as parking and special lane access. Getting the infrastructure out there is a huge issue for state and local governments. As far as we know, there are no profitable business models for recharging or hydrogen fueling infrastructure. Infrastructure is needed to make the vehicles a viable option, but such infrastructure will not be economically viable until a lot of people are using them (a catch-22 of sorts).

Philippe Crist: Early barriers and late rewards make sense. Are you assuming that in the future, much of the travel behavior will be like what we see today? What will travel demand be like in the future?

Greene: The study was done in 2013, and used the Energy Administration's projections of VMT. Yes, this research assumes the same travel behavior, and does not include autonomous vehicle.

URBAN MOBILITY SYSTEMS UPGRADE: HOW SHARED SELF-DRIVING CARS COULD CHANGE CITY TRAFFIC

Philippe Crist, OECD

Sperling emphasized the importance of climate change, but also touched on the convergence of autonomous vehicles and the sharing economy. In the next 30 to 40 years, it is possible for autonomous vehicles and the sharing economy to converge. This talk is focused on the "urban" and the "human." Autonomous vehicles will be deployed in cities.

Cities are hugely populated. They cover less than 5% of the Earth's land mass, and less than 1% of the Earth's surface. More than 50% of the global population is concentrated in cities; 70% of economic activity takes place in cities; 70% of GHG emissions comes from cities; 30% of cities are low-income informal settlements. People crowd into cities because they are formidable economic accelerants, for both the rich and the poor. In cities, there is greater access to labor markets and jobs, and more access to ideas and creativity. If we remove the buildings

from cities, we are left with a lattice with space allocated for transport and mobility. Transport and mobility are important functions in cities, but they are not the only function of the space between our buildings. When we only focus on how well spaces serve vehicles, we create inhospitable places for humans. But, the strength of our society rests in people.

It is estimated that humans will make 400 trillion trips globally from 2014 to 2050. Of those trips, 54 trillion will be additional to those we currently make today; 94% of those trips will take place in emerging economies and 97% will take place in urban areas.

Based on project population growth, the 21st century will be the Asian, African, and Latin American century. With an increase in population, there will be rapid increases in urbanized areas. Such growth poses formidable challenges for urban governance and sustainability. We need to become more creative at handling urban access and mobility issues in our cities.

How Shared Self-Driving Cars Could Change City Traffic: International Transport Forum, 2015

The study presented deals with a disruptive future urban pathway that could improve access. Most cars are used for less than an hour a day. We place great value on the convenience that cars provide. Other underused assets include homes, wifi bandwidth, and office space. Network technologies facilitate the sharing of these assets among individuals and some businesses. Car and ride sharing have become very popular, but they all require a drive behind the wheel.

Most car manufacturers anticipate that people will use autonomous vehicles in the same way that vehicles are used today. But, the researchers did not assume that.

What might happen if a mobility service based on a fleet of shared and fully autonomous vehicles replaced every car and every bus trip in a mid-sized European city? The study delineates the range of potential outcomes, but does not address how such a shift would take place. The city used in the study is Lisbon, Portugal, because the researchers had access to the data. The origins were real origins based on an origin and destination travel survey. The travel survey data, land use planning, and demographic data were combined to create a synthetic population of trips. The routes were authentic and based on the shortest time, and fewest detours.

Two vehicle configurations were modeled: TaxiBot (ride sharing) and AutoVot (car sharing). TaxiBots (trademarked name, so something else will have to be used soon), pick up and drop off passengers on routes that are optimized in real time. Two-, five-, and eight-passenger vehicles were modeled. AutoVots pick up one passenger or party at a time.

Those trips that were best served by the local high-capacity public transport (Lisbon metro) were assigned to the metro system, rather than a car. All car and bus trips were assigned to an autonomous vehicle. All trips under 1 km in length were assigned to walking. The researchers did not model cycling (the topography of Lisbon is not conducive to cycling).

Results

With both TaxiBots and a metro, a shared self-driving fleet would deliver almost the same mobility as now over a 24-h period, but with 10% of today's vehicles. The results are consistent with other studies that have been done in New York; New Jersey; Ann Arbor, Michigan; and Singapore.

During peak hours, a shared self-driving fleet would deliver almost the same mobility as now, but with 35% of today's vehicles. The AutoVots were less efficient, but could still remove nearly half the vehicles in the city during peak hours. Even without the metro, there would still be a

23% reduction in the number of vehicles running during peak hours if the AutoVots were used.

Parking

Under the AutoVot and TaxiBot scenarios all street parking could be eliminated, which would allow for the allocation of 1.5 million square meters to other uses (210 football fields, or twice the area of the Vatican, or increase the curb to curb street space by 20%). With more space, parklets and other shared public spaces could be added, or there could be more space for walking and cycling, or more space for deliveries or commercial activity.

Most cities devote a considerable amount of space to off-street parking. In the case city, Lisbon, 80% of off-street parking (surface and underground) could be released for other uses. In the TaxiBot scenario, 1.2 million meters of space (170 soccer fields), could be reallocated, which could allow for logistics redistribution centers that could be serviced by self-driving delivery shuttles.

Vehicle Use

TaxiBots and AutoVots would travel more than today's cars. In the TaxiBot plus metro scenario, travel would increase by 6% due to bus replacements, pick-ups, drop-offs, and repositioning. In the AutoVot plus metro scenario, travel would increase by 44% due to bus replacement and re-positioning. During peak hours in the TaxiBot scenario, travel would increase by 8%, and in the AutoVot scenario, travel would increase by 54%.

Without the metro, and only with the AutoVot or TaxiBot, travel would increase by 25% in the TaxiBot scenario, and 103% in the AutoVot scenario. The increased travel would have negative effects on congestion and emissions.

Road Occupancy

Carrying Capacity During Morning Peak (%)

	Base Case	TaxiBot + Metro	AutoVot Only
Motorways	36	+3	+64
Trunk roads	43	+5	+62
Distributors	34	+13	+76
Local Roads	17	+31	+115

In the models, traffic would increase significantly on the roads were it is currently much lower. This could lead to more conflicts with pedestrians and cyclists.

The results are consistent with other studies that have been done in New York; New Jersey; Ann Arbor, Michigan; and Singapore.

Electric Autonomous Vehicles

Only 2% more cars would be needed to handle EV recharging and range issues, and there would be beneficial impacts on emissions.

Policy Insights

Freed space must be managed to lock-in benefits: policies are needed to manage and reallocate freed-up space. Citizen input is important.

Managing increases in travel will not be trivial. The negative outcomes of the increase in travel could be mitigated. The relative increase in certain parts of the city will be more challenging to manage. The traffic increase could change the nature of certain residential streets, and make travel by active modes could be less attractive.

Currently, OECD member countries' policies focus on self-driving vehicles, not on their use. Policies address vehicle testing, licensing, and vehicle operation. Uses—such as long-haul road usage, shared taxis, or quasi-public transport—are highly regulated sectors that could face significant disruption with the arrival of autonomous vehicles.

Public transportation, taxis, and governance must adapt; 5,000 additional self-driving vehicles could handle all metro trips in a city the size of Lisbon that used either AutoVot or TaxiBots. There would be cost savings if the metro was replaced with self-driving cars. There will be significant labor issues if autonomous vehicles replace the metro and taxis. Taxis or public transit could utilize autonomous vehicles.

New business model and car models would be required. There could be a drastic decrease in the number of personal vehicles. It is unclear who would manage the autonomous vehicle and how they would be monetized. Governments can play a role in the regulatory and fiscal side. In the scenarios, vehicles are utilized much more intensely than before (an increase from 50 min to 12 h per day of use, and daily travel per vehicle would increase from 30 to 200 km). New car models will likely be needed, but a shorter life cycle will be induced, which will provide a quicker penetration rate for new technologies. Shared vehicles will have different interiors.

Data will be the fuel of 21st century urban mobility. Mobility as a service cannot exist without real time access to a wealth of high-velocity and personal location data. The data is a source of innovation and a source of worry. Location data privacy is an issue because there is currently an insufficient guarantee of trust. Regulation has not yet achieved an adequate balance between private and public interests.

Questions and Answers

Unnamed speaker: What did you assume about individuals who currently do not have access to transportation? Also, will the reductions in cost of travel affect increased travel?

Crist: We did not do any cost analysis. The study was more of an initial, exploratory exercise. We assumed from the origin–destination travel data that low-income households are taking the same types of trips. We are only looking at how the current travel data would apply with different technology.

Unnamed speaker: Have you presented this to Lisbon?

Crist: For a long time we were hesitant about revealing what city the data was based on. It was not our intent to talk about Lisbon. We have informally presented it to Lisbon. Also, we have presented it to car manufacturers and a few public authorities, and no one likes the study. All car manufacturers, except for one, have said that the autonomous vehicles are fantasy, not reality.

Citied–public transit representatives say that autonomous vehicles are antipublic transport. But, we do not feel that an autonomous vehicles system has to be antipublic transit. It could be a quasipublic transit service. It has to fall into a regulatory framework.

Gudmundsson: I find it surprising that no one likes the study. I would expect cities to be excited about all the space freed up if on-street and off-street parking was reduced or eliminated. There were some assumptions about the number of people in the TaxiBots. What about people who do not want to share with more than one person?

Crist: A lot of cities have been intrigued by the study. In Finland, they have a national policy of developing mobility as a service. I will be visiting Denmark's Transit Minister in 2 weeks. It was our prerogative to the set boundaries of this modeling exercise. In reality, there would be niche-based services that people could pay more money for single use of a vehicle, and vehicles of different quality. We are also looking at the concept of the Superbus, which is a mini bus that uses a route that is optimized in real time as people request pick-ups. For 5 years there has been a service in Finland called autobus. We are also looking at a transition scenario with mixed fleet use. Also, we will be looking at costs. Furthermore, we will be looking at cities for which we do not have origin and destination travel data. Some of our corporate partners will be able to provide data for such cities.

Unnamed speaker: I am interested in the cities that have not been built yet. How should future cities be designed to enable autonomous vehicles?

Crist: I anticipate an autonomous vehicle system first arising in a relatively wealthy Asian city. In one of the off-shore islands of Singapore, they are developing with MIT's SENSEable City Lab what we have presented. An autonomous vehicle system could provide all the trips that a traditional mass transit system provides, at potentially a lower marginal cost. If cities see an autonomous vehicle system in their future, they could plan for not having a metro, light rail, or BRT system. The real world is a lot more complicated than our modeled scenarios. There is no evidence at this time that people should be making investment decisions based on the modeled scenarios, but people should be thinking about potential changes to transport systems.

CONNECTED AND AUTONOMOUS VEHICLES OF THE FUTURE

Brian Cronin, Federal Highway Administration

- Today's transportation challenges:
  - Safety: 32,367 highway deaths in 2011; 5.3 million crashes in 2011; the leading cause of death for ages 4 and 11 to 27.
  - Mobility: 5.5 billion hours of travel delay; urban congestion costs $121 billion.
  - Environment: 2.9 billion gallons of wasted fuel, 56 billion pounds of additional CO_2.
  - These issues are all interrelated. If there are fewer accidents, there is less congestion, if there is less congestion there may be less of an impact on the environment.
- Connected vehicles:
  - Data can be used to improve safety, mobility, and the environment.

  - 5.9 gigahertz Dedicated Short Range Communications (DSRC), essentially a Wi-Fi radio. A notebook-sized piece of equipment that can be added to infrastructure or a car to send and receive data.
- Connected vehicle deployment:
  - What are the mobility and environmental applications of connected vehicles?
  - During the summer of 2015, the FHWA will issue guidance for state and local agencies.
  - This technology will likely be in vehicles around 2020.
  - Currently, pilot sites are being selected. There was a safety pilot in Ann Arbor.
- Connected vehicle applications:
  - Vehicle to Intersection Safety: spot weather impact warning.
  - Vehicle to Vehicle Safety: blind spot/lane change warning.
  - Agency Data: probe-based pavement maintenance.
  - Environment: eco-approach and departure at signalized intersections.
  - Road Weather: weather response traffic information.
  - Mobility: intelligent traffic signal system, freight-specific dynamic travel planning and performance.
  - Smart Roadside: smart truck parking.
- Sample deployment concept:
  - Improve transit reliability: Connection Protection, Transit Signal Priority.
  - Improve pedestrian safety: Pedestrian in Signalized Crosswalk Warning, Intersection Movement Assist.
  - Improve Air Quality: Eco-Approach and Departure at Signalized Intersections (the car could slow down as it approaches a red light so the driver would not slam on the breaks), Eco-Traffic Signal Timing.
  - Synergies among applications increase benefits and reduce costs.
- Eco-lanes are dedicated freeway lanes that feature variable speed limits, eco-cooperative adaptive cruise control, and wireless inductive–resonance charging infrastructure.
  - Variable speed limit systems reduce congestion, provide reliable journey times, reduce the frequency of accidents, reduce carbon emissions, and reduce driver stress.
    - Reducing speed limits on a freeway from 65 to 55 mph on a Code Red Air Quality Day reduced NO_x by 17% over a 24-h period (University of Texas, Austin, study).
  - Safe Road Trains for the Environment demonstrations indicate up to a 16% reduction in fuel consumption for following vehicles and an 8% reduction for the lead vehicle.
  - Eco-cooperative adaptive cruise control and vehicle platooning.
  - Eco-lane equipped with wireless inductive–resonance charging that is connected to a smart grid.
- Communications security policy:
  - Vehicles need to be able to trust the data that comes from other vehicles (for instance, a Toyota needs to trust a Ford), and from the infrastructure.
  - A security credential management system is required.
- Connected–automated vehicles:
  - An automated vehicle communicates with other vehicles and the infrastructure to self-drive.

  - An autonomous vehicle is self-contained and does not interface with infrastructure or other vehicles.
  - Connected vehicle technology can improve all types of vehicles.
- CityMobil2. A fully autonomous transit type vehicle was tested in France. It traveled 5 to 10 mph on an intensely defined map.
- Current demonstrations: Nevada is now allowing truck platooning operations.
- TRB Automated Vehicle Symposium, July 20, Ann Arbor.

Questions and Answers

Gudmundsson: This presentation was more about vehicles, infrastructure, and technology, whereas the previous presentation was about humans in the urban environment. What is the role of humans in a connected system? There probably will not be transmitters on people. How will vehicles interact with humans in this environment? Will everyone need to carry a transmitter to be safe? What if people do not cross the street at the signal?

Brian Cronin: Many cellular companies are adding DSRC technology to mobile phones.

Shaun Bortei-Doku: I have read about the intricacies of dynamic technology. For example, if one side of a road is congested and cars are piling up, would cars or infrastructure be used as broadcast nodes?

Cronin: In Europe, people are advocating for the use of cars as communication hubs between vehicles. The capability to communicate between vehicles will likely be available.

Robb Graff (online): Can you speak to the importance of market forces versus strong mandates?

Cronin: NHTSA is planning on regulating a communications device. It will not regulate the applications of the device. The FHWA is not regulating this technology. They are providing standards and information on best practices, which can be used by state and local governments to make choices.

Crist: Humans, cities, and lawyers. The FHWA is not regulating connected vehicles, but are you providing advice on the allocation of responsibility in the event of technical failure? Will that be up to the 50 individual states?

Cronin: Yes, that is an unresolved issue. The automobile industry is very worried about liability. We are providing warnings for connected vehicles, we see the liability as no different than what exists today.

BREAKOUT GROUP A

Developing Countries
Challenges on the Path to Sustainability

RALPH HALL
Virginia Polytechnic Institute, presiding

Hall is chair of the research subcommittee of the Sustainability Committee. He used the GapMinder software to show the global change in fertility rates over the past 200 years. Today, the highest fertility rates are found in sub-Saharan Africa. One can change the data represented on the *x* and *y* coordinates to visualize a multitude of information. GapMinder is a useful tool for visualizing changes in population data over time. It's difficult to contextualize "developed" and "developing" countries because there is a continuum, and it is often a dynamic situation. We should talk about developing countries in a specific, rather than general, way.

- Travel time to major cities: a map showing how many days people would have to travel to reach a city with a population of 50,000 (European Commission):
  - 95% of people are concentrated on 10% of the land, and
  - 15% of people in developed countries are more than 1 h from a city; in developing countries, it is 65%.
- Growth in the global classified public road network from 1998 to 2008:
  - Percent paved in 1998: 51% (world), 59% (United States), 18% (China), and
  - Percent paved in 2008: 57% (world), 67% (United States), 54% (China).
- Transportation challenges:
  - Increasing urbanization,
  - Increasing vehicle ownership,
  - Inadequate hierarchical highway, road, street systems with poor infrastructure for nonmotorized transport (crowded streets), and
  - Lack of capacity to plan or manage transportation systems (a skills gap, for example in India, a certain number of people is required to build the infrastructure people want):
    - Inadequate public transportation systems,
    - Limited financial resources, and
    - Inadequate implementation and enforcement of transportation and environmental laws.
- Transportation-related impacts:
  - Increasing use of nonrenewable energy (climate change):
    - In a graph of carbon emissions from energy consumption, the United States is in a downward trajectory, whereas China's emissions are on a steep incline.
    - China has agreed to level off their emissions by 2030.
  - Increasing transportation-related pollution.
    - *Under the Dome: Investigating China's Smog* is a documentary that provides useful information on transportation-related pollution (a *Silent Spring* for China).
      - China completed an industrialization process that took other countries 100

years.
    - Ocean-going cargo vessels cause so much pollution that within 400 m of the coast emissions from ships are equivalent to emissions from 500,000 trucks.
    - In 2003 there were 100 million drivers, in 2010 there were 200 million drivers, and in 2014 there were 300 million drivers. Within the next 4 years there could be more registered drivers in China than there are people in the United States.
  - According to the Intergovernmental Panel on Climate Change, transportation is responsible for 14% of direct GHG emissions.
  - There is more growth in carbon-related emissions in upper-middle-income countries than in higher-income countries. Upper-middle-income countries include South Africa, Brazil, Venezuela, Colombia, Cuba, Algeria, Jordan, Mexico, Argentina, Hungary, and Thailand.
  - There is a tremendous amount of embodied carbon associated with the United State's imports of goods from China. The U.S.–China trade deficit is –$267.4 billion.
    - Increasing congestion that reduces mobility and accessibility, and
    - Increasing number of accidents (1.24 million deaths annually).
  - Poor road user behavior: driving under the influence, speeding and aggressive driving, lack of police enforcement, and distracted driving.
  - Unsafe vehicles: lack of vehicle regulations, poor control of vehicle, vehicles are not well equipped for the road.
  - Poor roadway design: inappropriate speed limits, a lack of pedestrian and bicycle facilities, inadequate roadway layout and design, and a lack of safety regulations.

- Research questions:
  - How might the post-2015 agenda impact efforts to advance sustainable transportation in emerging economies?
  - How do we finance "sustainable urbanization"? (Holger Dalkmann)
  - How do we avoid the "lock-in effect" from investing in high-carbon related transportation infrastructure? (Jose Luis Irigoyen)
  - What opportunities exist to "green" transportation metrics in developing countries? (Jose Luis Irigoyen)
  - How can we leverage "green" (sustainable) TOD to address sustainable cities in China? (Kang-Li Wu)
  - What is the appropriate balance of "advancing" versus "constraining" transportation options for sustainability? (Philippe Crist)
  - How do we address the gap between urban planners and transportation professionals? (Yang Jiang)
    - Success requires partnerships and full engagement, and bringing more science to policy (Dan Sperling's keynote).
  - How might developing countries leverage new mobility options? (AutoVot, TaxiBot, connected vehicles)

QUESTIONS AND ANSWERS

Hall then invited participants to gather around for a group discussion.

In the room were Julyana Shalders Moulin, Amit Arora, Rich Baldauf, Todd Litman, Kang-Li Wu, Brian Cronin, Ernesto Monter, Sara Maurer, Philippe Crist, Shaun Bortei-Doku, Yang Jiang, Howard Glassman, Jacob Berlstein. Online: Bruce Appleyard, Burr Stewart, Gui Shearin, Beth Zeitler.

Crist: In emerging economies, many transport professionals get training in developed countries, but what they learn is not well adapted for the local situation.

Cronin: In a developing country, would it be easier to implement new technology (e.g., autonomous vehicle) because there would be less bureaucracy and fewer rules?

Crist: In both developing and developed economies active transport plays an important role. In a lot of cities in developing countries many people walk, and transport professionals often do not quantify walkers and cyclists, they are more interested in counting the number of cars.

Jiang: I agree with you. People often measure what they care about. Many transportation professionals care about cars. Research should look at all modes of travel, not just cars. In China, we have started including surveys that consider no-car modes so that we create streets that are more bike and pedestrian friendly. After the streets are improved, it is important to have a post-improvement evaluation. Developing countries need new policies, pilot projects that can demonstrate innovations, and more research.

Litman: There is some great work happening in developing countries. In India, research groups have developed roadway design manuals and have done great pedestrian planning. But, in developing countries, there is a lack of sharing of professional development best practices. In developing countries, there may not be the equivalent of a local American Planning Association or Institute of Transportation Engineers. Such associations are important for bringing people together for collaborative learning in an informal setting. In developing countries it is more top down, with a few professors that are considered experts. We should find ways to encourage local and regional organizations in developing countries because they are useful for sharing new ideas among practitioners. On a different note, standardizing data collection is very important. TRB needs to be part of the Global Transport Intelligence Initiative.

Perlstein: When I assess a project, the pedestrian is my number one client. Secondly, I consider transit users. Thirdly, I consider cyclists. Lastly, I consider transit and cars. I consider how much transit users have to walk and what is involved in transit transfers. In Israel, we are looking at how much we are investing in terms of GNP, transit planning and infrastructure, and roads; 70% of the western population is using the car. We need to continue investing in transit.

Glassman: The issue that Brian brought up, government regulation and technology, is important. Uber and Lyft have come to the state legislature (Florida) and they want state preemption. They want state government to control the regulation of their activities, and want to prohibit local regulation. Developing nations may have an advantage over developed nations when it comes to centralized decision making. American decision making is more bottom up. In the United States, local authorities will have to relinquish some of their transportation authority to make new systems work. Institutional arrangements could be a good research topic.

Wu: Sustainable transportation planning has multiple goals, including social equity, environmental quality, and economic efficiency. In China, we have to prioritize things. Economic development is most important, social equity is probably the second most important issue. TRB can help a developing country like China improve its transportation system, without copying the transportation systems of the United States or Europe. A lot of people in China think big and fast are best; they want wide streets. Decision makers need to know that big is not always best, they should support policies that build for what it is needed. Developing countries should think about what they need, and not just emulate what other countries have.

Crist: TRB is not helpful when it provides a menu of options that are not based in strategies or principles. What type of principles should guide action? Things that are not being talked about through TRB may be more important to developing countries (such as improving transportation access, rather than improving transportation speeds). A lot is happening in emerging economies, and we can learn a lot from them.

Arora: In India, there are professional societies, but they are not diverse enough. They need to be comprised of different disciplines. We may be publishing great manuals, but we still rely on bureaucrats for implementation. The exchanging of ides, rather than the "teaching" of ideas is important. In India, we are moving toward considering pedestrians and transit users. Data collection is important, but it is also very important that that data be available to others.

Litman: We are in the middle of a paradigm shift, which is not just a change in technology or methodology; it is a redefinition of problems. Until recently, transportation was defined as vehicle travel. The new paradigm is accessibility and multimodal transportation. Transportation engineers are thinking about complete streets. As researchers, we want to cast a wide net for data because we cannot anticipate what data we will want in the future. It's our responsibility to have a vision for the broad scope of information, and to have standardized formats for surveys. TRB needs to do a good job of identifying the components of the paradigm shift, which include multimodalism, the integration of transportation and land use, sustainability (and its three components), disaggregating populations in more fine-grained ways (e.g., be able to know travel behavior of young people).

Jiang: I agree with Todd that it is important to standardize data, but it is also important to build a database on best practices. In China, there is an initiative to support cycling and pedestrians, and last year 100 cities participated. TRB can help by looking at best practices and successful projects in developing countries, and that information can then be shared with decision makers.

Bortei-Doku: At Danish Technical University, a project was introduced where people from all over the world could offer data (for free or for a charge), and subsequently rate the data and research.

Hall: As an academic, I often think about how to structure and design courses. I think we could have interesting collaborations between students in the United States and students around the world. Maybe TRB could facilitate relationships between students around the world. There are probably similar versions of the same courses in a lot of countries. In one of my classes, U.S. students are collaborating with University of Kanpur students.

Appleyard (online): We should move beyond a simple laundry list of indicators and move toward developing more straightforward frameworks for measuring, understanding, and then ultimately achieving sustainability. Let us not limit ourselves to solving transportation problems through transportation-based solutions. Land use, housing, and urban design policies and practices are often more effective at solving sustainable transportation problems. We need to integrate these professions into our work.

Stewart (online): Interested in visual methods of communicating sustainability.

Shearin (online): Interested in estimating risks associated with approaches to climate change, and how to bridge the gap between research and government policies and actions. Also, drivers think they are more important than cyclists or pedestrians. Many drivers do not share common space, and bully their way through. A behavioral approach that addresses attitudes as well as behavior is important.

Online: If BRT is 10 times more cost-effective than rail, what about bicycle separation? What makes the most sense when cities have few resources? How can we disseminate these ideas for inexpensive urban development?

Stewart (online): Today, more 8 year-olds are alive than will be in the future as birth rates will decline as more people move into cities. The world population will peak in 2050. We have to start planning for a decline and thinking about life-cycle analysis in terms of fewer users and or less demand in the future. What kinds of changes will this bring to project planning and economic analysis?

AlJammal (online): Interested in regional level sustainable transportation systems. Curriculums need to change so that transportation engineers are designing roadways and transportation systems for humans not cars. The mobility experience, which would consider physical experiences such as noise, vibrations, air, sights, social interaction, and physical activity, should be studied.

Zeitler (online): How do you engage civil society and the public as stakeholders when planning–building–making decisions at a national level? How might that be done in developing or developed countries?

Stewart (online): We need to research the data frameworks that are out there, and help people see how similar they are, in order to arrive at a "universal system of sustainability frameworks and data."

Stewart (online): Also, one of the speakers mentioned the Deming quote about the role of a unit in contributing to the efficiency of the whole system. How can we promote research that looks at the urban system as a whole and the role of transportation in it? It could be that we are looking at transportation efficiency too narrowly, and should be looking at urban system efficiency as a whole.

Stewart (online): Sperling's point yesterday about the importance of two-page "decision memos" is very true. We need to standardize the format of a "global local policy memo," and do research to

populate such memos around the world. There is a lot of duplication in people's efforts. I am interested in joining Litman in a TRB task force on "frameworks."

Stewart (online): If a developing country can devote 60% of their budget to nonmotorized transport, developed countries should spend more if they hope to compete in the future.

Zietsman: In developing countries, a big issue is who will pay and where is the money coming from? We need to find ways to partner with multilateral banks. How do we get the banks to spend on strategies we are interested in? In terms of what people learn in developed countries and bring back to developing countries, maybe there is a different way to share what should be taught. Maybe courses can be adjusted so they can be a might more universal and a bit more global.

Arora: If I search the Internet, I will find very few papers on transportation in developing countries. TRB can facilitate a broadening of research subjects. Also, we use the term "sustainability" all the time, without understanding what it is. Outreach on sustainability at a young age (i.e., kindergarten through 12th grade) is important.

Hall: Jay Forester, who is a computer engineer and developed system dynamics, also said he would work with children from kindergarten through 12th grade to change the way that people address problems from systemic perspective. If people look at problems from a systemic view from an early age then they can come up with better solutions in the future.

Arora: Learning about important concepts early is very beneficial.

Monter: I am new to TRB and the transport sector. When I started my career 25 years ago I was working for the government of Mexico City. I now work for the Inter-American Development Bank (IDB), which is interested in sustainability, but within the bank there are different ideas about what sustainability means. Sustainability can be interpreted differently by different sectors. Can sustainability go beyond compliance? Can TRB help refine the scope of sustainability for banks or other agencies looking to advance the idea? Cost reductions and support from the community are very important to decision makers.

Hall: If we have a call for papers, and researchers and practitioners in Latin America are writing papers, could the IDB fund their travel to TRB?

Monter: We were able to finance the participation of five people from Paraguay for this conference. The IDB is interested in bringing people to Latin America, and facilitating the travel of Latin Americans in order to learn more and exchange ideas.

Arora: Traveling from other countries to TRB is expensive, which is why online conferences are so important.

Litman: Web-based professional development would also be useful. They could be cosponsored by IDB, the World Bank, and TRB. The practitioners need to hear more about the new paradigm. Every year, the World Bank cosponsors Transforming Transportation. I enjoy that even more than TRB's annual conference. TRB, the IDB, and the World Bank could partner with transportation

professional organizations could have ongoing, online, professional development workshops.

Cronin: The FHWA is doing something like that now. We are doing flipped training, which means that all the presentations are but online, and then people come together for a dialogue based on what was presented. Flipped training is being used to train stuff all across the country. They are generally PowerPoints accompanied by audio recordings, followed by a quiz. The dialogues facilitate a deeper understanding.

Litman: In developing countries, such as India and China, do practitioners need to get continuing education credits? No? Continuing education credits drive a lot of workshops and conferences in the United States and other places. TRB and professional organizations could create incentives for obtaining continuing education credits, which would bring more people to dialogues and would stimulate the exchange of new ideas.

Jiang: In China, we do have a certificate system for urban planners. To become a Certified National Planner, you have to take specific courses. To maintain your certificate you have to attend certain conferences, which are generally held in China. It might be possible to add TRB conferences to that system. My organization (Sustainable Transport Center, Tsinghua University), has been pushing for a textbook for the certificate exam. If the principle of sustainability is in the textbook, then more planners will learn about it. In terms of stakeholders, nongovernmental organizations and philanthropic foundations are also important collaborators and stakeholders. Financial support is important for technical studies, not just for investments and construction. Lastly, we should consider the automobile industry. What is the limit of growth for cars? What can we do to counter their lobbying efforts?

Zietsman: The conversation that just took place is very much in line with the Transportation and Sustainability Committee, the mission of which is to be the clearinghouse for transportation sustainability. We want to be the go-to group for sustainable transport, but we do not go very deep into sustainable transport issues. I agree with Todd that the January meeting with the World Bank is a good place to meet with stakeholders. Within Transportation and Sustainability Committee, we have a communications subcommittee, which could potentially help coordinate sustainability discussions with other stakeholders.

I was inspired by what Stewart added to the GoogleDoc about frameworks. Hall, Gudmundsson, Marsden, and myself have been working on the book *Sustainable Transportation: Indicators, Frameworks, and Performance Management* for the past 5 years, and it will be published soon.

Ralph Hall: The book includes case studies, which show how performance measures, frameworks, and indicators are used in reality.

RESOURCE

https://docs.google.com/document/d/1R74FyXsawDTiCs7FcVi85 PcvltS4CkVtApcsBNgumGk/edit?pli=1.

BREAKOUT GROUP B

Practitioner's Guidance on Implementing Sustainability

STEVEN OLMSTED
Arizona Department of Transportation, presiding

Olmsted began by explaining that one of the goals of the discussion was to identify gaps in research and how that relates to the role of state DOTs. The Arizona DOT was involved in beta testing in 2011of the INVEST Systems Planning Component. In 2013, there were grant opportunities to implement INVEST. Within the DOT, Olmsted is in the environmental planning section, which deals with the 5-year construction program, environmental compliance, NEPA. In the early 2000s, Olmsted worked with Arizona DOT on program planning, audit finance, and resource management. Olmsted said that participants should not underestimate the power of available research. Arizona DOT has a research arm. Research has been very helpful in supporting sustainability at Arizona DOT. There are six volumes on sustainability in the foresight compendium of TRB and professionals should take advantage of easily searchable databases.

Olmstead spoke briefly about the state of the practice from a state DOT perspective. A common conference theme identified boils down to identifying what roles different entities play within National Innovation Systems (NIS). In this case, it is a national system for sustainable transportation. Some national systems are further down the continuum while other countries are just leaving the gate. Complicating the continuum is the quality of innovation and specifically how dynamic the institutional factors are (e.g., public policy) and incentives are linked. Furthermore in the context of sustainable transportation, economic, social, and environmental considerations must be layered in. There is thus a rich variety of possible roles to address the elements of a national system for sustainable transportation. Where do you start? Policy? Financing? Stakeholder outreach? However, no matter what NIS you are part of, focus on what you are passionate about, and contribute to your particular NIS by striving for an equally weighted system of financiers, stimulators, facilitators, and implementers. The FHWA was a financier for Arizona DOT.

In closing, in some respects the state-of-the practice seems to be an assault on traditional road-building activities. In traditional road-building activities, there are ways to implement sustainability. However, it was proposed that the conversation gets rotated to better match the reality of managing long-term asset management, with the goal of accelerating the adoption of all-modes-complete transportation models.

Arizona DOT has 30,000 maintenance lane miles spread over 114,000 mi^2 (Arizona is almost the size of Namibia), 4,750 bridges, and an international border with Mexico. The DOT has a $2 billion capital program and a $400 million operating budget. In 2013, the agency started to develop an Intermodal Transportation Division (ITD) sustainability program, and an extreme weather and resiliency program.

Arizona DOT has 4,300 employees. ITD is tasked with delivery of the $2 billion 5-year construction program. Arizona DOT's Sustainability Program and INVEST Implementation Report, developed over the last 14 months, was submitted to FHWA in April 2015. Like the UN's Sustainable Development Goals, Arizona DOT wove sustainability throughout the

agency's goals, starting with ITD. In other words, ITD did not have a separate sustainability goal. Arizona DOT systematically operationalized sustainable transportation as an activity. You have to pick an entry point, no matter how small.

The agency started with the approval of an Excellence in Sustainable Project Development Award, which was sold as a competitive tool to the state engineers office for districts to identify best management practices. This was followed by a 24-month INVEST effort, which lead to a second INVEST effort covering maintenance and operations, and the sustainable pavement solutions pilot.

Texas DOT's Harbor Bridge project is a further example of how DOTs are trying to become more nimble and responsive. Sustainability is thus not only gaining footholds, but creating new and novel formats to address very traditional planning, programming, design, construction, maintenance, and operations dynamics.

Omlstead concluded his presentation by noting that he disagreed with the notion of a chasm between policy and legislation. He urged transportation professionals to lead by example and bridge the chasm by delivering sustainable transportation approaches that allow legislative activities to seamlessly plug into areas of interest to those bodies. In other words, package the approaches as they relate to trade, commerce, social, economic, land development, etc. Arizona is doing this by including the INVEST Tool as part of the environmental impact statement process and environmental alternatives review for the future I-11 (Canamex corridor), connecting Mexico and Canada. Arizona DOT went to a lot of the early environmental planning meetings to design the scope of work, and proposed the utilization of the INVEST tool to help develop alternatives. The initial environmental assessment for the project will cost $10 to $15 million.

The big question relates to aging infrastructure. In other words, what is the desirable approach to balancing capital for new modes versus the amount and rate of capital investment to maintain the legacy system's infrastructure (i.e., maintenance of the deteriorating highway system)? Olmsted agrees with the comment someone made earlier that transportation has barely evolved in the past 70 years. There has been a lot of change. Olmstead concluded that transformative and foundational change is possible.

The participants were divided into three groups of five to discuss six questions:

1. Rank in order 1 to 10 (1 being most influential) which of these new next generation sustainable transportation considerations could have the largest impact on your national systems:
    - Peer-to-peer car sharing.
    - EV sales surge.
    - Vehicle light weighting—ultralight, ultra-efficient (for example, the body of a Ford F-150 is now made of aluminum).
    - Smarter parking and cities, intelligent transportation systems.
    - Autonomous vehicles.
    - Freight carbon footprint and the supply chain impacts.
    - Big data and transportation efficiency.
    - Fixed transit: trolley, street car, light rail, high-speed rail.
    - Pedal power and bike-sharing programs.
    - Youth education and stakeholder outreach. (Globally, more youth will be entering the middle class; what will they want in a transportation system?)
2. List the three leading impediments to further implementing sustainable transportation

systems in your respective national system.

3. Describe the weakest areas of sustainable transportation in your national system as they relate to planning, design, project development, construction, maintenance, and operations. For example, new systems in small countries may attract a lot of attention from larger engineering firms because the country has received outside funding. How does one facilitate the participation of local consulting firms (engineering, etc.), especially if they are not as knowledgeable on sustainable transportation, so they do not feel excluded from the process? Of course, the larger firms can be required to utilize local firms when possible. Education is also important to sustainability.

4. Have the successes and/or lessons learned in your respective national system been operationalized and how were they successfully, or not successfully, linked to public policy, community outreach, and government incentives? (Give examples.) Is your group the only champion of sustainability?

5. Simply list global, national, regional, or local entities that do contribute, or you would like to contribute, to each of the four equal weights one might desire in a balanced national system. Assume that you are starting a brand new system. The goal is list your entities where they would be, and other stakeholders that would contribute and where they fit:

- Financiers,
- Stimulators,
- Facilitators, and
- Implementers.

List your agency and other stakeholders that you know. It may be easier to list financiers and implementers than it is to list stimulators and facilitators.

6. In order to initiate those continuous waves of social adoption of sustainable transportation ideals within a given national system what tools, education, outreach, research, guidance would be needed or of most value (imagine you are part of a system just getting out of the gate)? For example, you could list the tools in the question, and what would be most beneficial for scaling up. You could include academic research, social media, and community outreach. For developing countries, how would you train the local contractors and firms to compete with larger firms. Also, what is the one thing that each of you like to use as a tool? Do you focus more on acquiring research?

Participants were encouraged to imagine that they were part of a transportation system that was "just getting out of the gate," so that they could better develop new systems and new solutions.

QUESTIONS AND ANSWERS

Steven Olmsted: Sustainable transportation activities have been established. Where do they plug in? How do you go further back in the cycle than project development? Look at the construction program look at cycles. Currently, we are looking at the back end of the 5-year program. At Arizona DOT we used the INVEST tool to look at the back end of the program. How do you develop a process, to get the community, policy makers, and legislature to incorporate sustainability into projects that still have to enter into the 5-year program?

There are three circles: things that we can do to affect things that are not yet under

construction, projects that are entering construction and are in the planning phase, and the pre-planning phase. Following the small group discussions, the participants reconvened to discuss the issues as a group with input from those present and those participating online. The following paragraphs document this discussion.

Jeff, Oregon DOT (online): Besides institutionalized use of rating tools, what are effective means or methods to capture or report data that demonstrates success in project design and construction? How do you blend what is just required (engineering specifications), and track the sustainability characteristics that you want to implement? How would you take a project that has gone to design, how would you track the sustainable additions?

Roger Venables: In CEEQUAL, you can use the tools at a program level to influence criteria that you set for success. You can then use the tools on every project, but that might not be the best use of the tools. You can have a mix of verified assessments, and unverified assessments within a program. You then use the tool to track the project to understand what you dealt with, and what you have not dealt with. A preassessment spreadsheet can be used to track how far forward you are getting in your thinking. Internal systems can also be used to decide the top priorities that people are worried about, and spreadsheets can be constructed to track those.

Olmsted: How might one document or tracking goals as a project gets implemented?

Unnamed speaker: We have our seven goals, and then we would set up a project team. We would create a document to list activities that are linked with different goals. We need to track activities and periodically check on things.

Mike Culp: This is system planning problem. The profession is moving towards performance measurement. Usually performance measures align with goals you are trying to achieve. One can use a tool to help define performance measures or use a process to identify performance measures. One needs to take a step back from the project to contemplate how the complete system works together. So performance measures may be different for the system and for individual projects. INVEST has a module that only addresses planning issues (to get at system level issues) that differ from project assessment. As long as the goals and objectives align with the principles of sustainability, you are on the right track. The goals and objectives are implemented through a project management process.

Olmsted: At Arizona DOT, our approach was more ad hoc.

Unnamed speaker: FHWA is using INVEST to develop an operations and maintenance module with Arizona DOT. We are conducting surveys with district engineers and environmental coordinators.

Antoinette Quagliata: FTA uses environmental management systems, and they have a new transit system that is just starting. Such tools set a framework for identifying goals and targets. Monitoring, record keeping, and data collection are all important. The system can be revised over time. Frameworks help you to implement changes and track progress over time.

Bill Nolkes (online): There is no consistent definition of sustainability. Practitioners need to see clear and coherent goals.

Seth Stark (online): How do you tie goals to legislative mandates?

Olmsted: Sustainability is a new area for practitioners. Change is fluid and takes a long time.

BREAKOUT GROUP C

Factors Affecting Demand for Transportation and Impact on Sustainability

GIOVANNI CIRCELLA
University of California, Davis, presiding

Giovanni Circella provided an introduction to the roundtable style presentation and discussion and invited all participants to actively engage in the session. The format was not intended to be formal; it was designed to encourage deliberative dialogue in addition to a few prepared slides. The National Center for Sustainable Transportation at UC Davis had a particular interest in the session's topic. The overall purpose of the session was to discuss key findings from the conference, as well as any relevant research needs.

A portion of the discussion was allocated for mobility trends, particularly surrounding VMT. While there has been a rise in VMT, average VMT has plateaued and, in some cases, decreased. This peak occurred in the United States around 2005 and has since declined. Potential causes could include the recession, however, this trend started slightly before the recession. This trend is also occurring globally. While the United States has higher VMT than other countries, on a global scale there is a recognized pattern in declining VMT.

Car ownership was another topic broached within this session. The percentage of households living without a car has increased, both in the United States as a whole, as well as in larger cities which already have higher percentages of households without cars. However, in 2015, there has been an uptick in VMT. While the reason is unclear, the economic recovery from the recession is most likely to be a factor in this new change in driving behavior.

In regards to developments in urban form, many cities are experiencing a surge of growth in their central core, a growth that is much more rapid that adjacent suburban areas. It is theorized that this growth stems from younger populations relocating to the city, as well as an abundance of mixed-use housing to accommodate such populations. This development is usually accompanied by an increase in transportation investments. In regards to the future of suburban communities, this growth could be a potential harbinger for suburban decline. For example, from 2000 to 2010, the city of Atlanta experienced an increase in urban core growth that greatly outpaced that of the suburbs. The majority of the demographics contributing to this growth are young, highly educated professionals. Along with this increase in growth, there is also an increase in the vertical growth of the building, as seen in new high-rise buildings.

Because of this trend, understanding the desires and transportation needs of millennials are critical and there has recently been a new interest in researching this demographic. The term "millennials" encompasses people ages 18 to 30 or 35. Millennials adapt much more easily to living without a car and are typically first adopters of new technologies that facilitate such adaptation. Millennials are largely more educated than older generations and are typically postponing marriage and families and opting to live in smaller households, as opposed to older generations who are typically anchored by their families and large homes. These factors combined poise them to adopt an auto-independent lifestyle with ease. However, there is very little data on whether this trend is only occurring in the United States or if the data is statistically significant enough to make these larger assumptions as to the articulated desires and living

patterns of this very diverse demographic. Furthermore, existing research is primarily derived from convenience samples, such as groups of students, which could result in skewed and myopic results.

In regards to new technology within the transportation industry, car sharing, GPS, and the ability to multitask on public transit have allowed people to opt for public transportation more easily and result in lower levels of car ownership. However, ride sharing with private sector companies, such as Uber of Lyft, can result in decreased use of public transportation. These services are typically cheaper than taxis and are seen to have greatest utility late at night when public transportation is not running. However, these private-sector companies are typically not willing to share their driver and passenger demographic data, resulting in speculation as to its overall role in the future of transportation behavior.

There are several factors that can be attributed to these changing travel demand trends. Traffic congestion, the growth of public transit (however, this growth can be uneven as there are some municipalities who are cutting funding for public transit), the reversal of suburban sprawl in the United States, and the promotion of Smart Growth, TOD, and compact development. There is rising popularity and preference for "urban lifestyles and culture," however, it must be noted that suburban communities are still an indicator of higher social status for some groups. Furthermore, with gas prices experiencing turbulence, recent research has shown that this elasticity of demand informs traffic patterns, particularly when prices are high. Economic cycles also contribute to new mobility patterns, most readily seen in the boomerang effect where people are moving back in with their parents due to economic necessity and higher levels of unemployment, leading to lower amounts of travel. However, there is a division in this realm of research where some find that travel demand increases inversely with economic growth and sometimes it does not. An example of this is the rise in telecommuting which may decrease travel demand, but not due to economic decline.

In regards to changing demographics, the United States will experience an unprecedented aging population as the baby boomer generation begins to age and retire. Combined with more young people receiving higher education and the trajectory of their lifestyle choices, it is yet to be seen how these changes will affect travel demand. However, geographic location and generational differences can have a strong impact on travel patterns. Projecting future trends is difficult though. Determining what is permanent versus temporary changes is an inscrutable endeavor, particularly with the volatility of the changing economic landscape in the United States. Understanding if these trends are occurring exclusively in the United States or are part of an overall evolution in travel demands is also an area of research that is currently underway. Furthermore, integrating the role of technology in these changing trends, be it a substitute for travel or a conduit that promotes travel, is another valuable area of research.

Following Circella's presentation on transportation demand, the following observations were made during the group discussion.

QUESTIONS AND ANSWERS

David Greene: In the United States, we have experienced a long-term gradual decline in the rate of growth for VMT. This is determined by key drivers: who has a license, who doesn't, and how many cars belong to each licensed driver. These factors are reaching a saturation point—some drivers have multiple cars and the United States is approaching an almost 100% license rate for

most groups. After this saturation point has been met, the rate of change for VMT is very sensitive to economic factors like income, price of travel, and price of fuel. The income growth in the United States has been fairly uneven, with the top-earning groups of the United States typically absorbing the profits of this new growth and the bottom 80% experiencing a widening class gap. Growth of travel is affected by income, distribution of income, and price of travel per mile and VMT is correlated to these factors.

Giovanni Circella: I agree with your points on saturation and support the statement that aggregate income is not the most helpful lens to understand travel demand when the effects of inequitable income distribution are not included.

Regina Clewlow: How does income affect people's housing choices? There is as much data that supports younger people wanting to reside in the suburbs as in the urban core.

John Rezobith: The unique attributes that characterize millennials, particularly high student debt, affects their lifestyle and automobile ownership choices. This poises them to be much more comfortable with other forms of transportation.

Sarah Overmyer: It seems short-sighted to stipulate that "everyone" is moving to the urban core because rent prices and congestion are also reaching their saturation points. High rent, combined with high student debt, can inform these lifestyle decisions. She believes research should focus on understanding the ebb and flow of people over time, rather than just only focusing on relocations to urban areas.

Clewlow: There is an abundance of research that confirms that young people actually do desire to move to the suburbs and that acknowledging the distinctions between various suburban communities would allow for greater insight into this trend.

Circella: I support the idea of differentiating between different types of suburbs through the possible creation of a typology. There are also differentiations between cities in geographical areas (i.e., Austin versus San Francisco versus Salt Lake City) which require this type of comprehensive analysis.

Teresa Adams: There is evidence that millennials would rather give up their cars than their cell phone and that cities are becoming more dense.

Dana Jaffe: What are the years for the studies you cited in which you said that cities are becoming more livable? Student debt is an important contemporary factor in the development of housing and transit choices.

Adams: I am not sure of the publication dates, but they are recent. She also believes that younger people are more interested in environmental sustainability and values inform their choices substantially.

Greene: There is validity to all that has been previously discussed. However, in response to the comment that young people would rather live without a cell phone than a car, he believes this is

because phones are much more inexpensive. It has been very difficult for graduates to find work and that the evolution of choice is based on affordability. VMT can be partly explained by significant changes in fuel prices, even though travel demand is strongly elastic.

David Proffitt: Economics matter in this discussion, but we are also experiencing a very interesting time in understanding development patterns. Housing development is a larger driver of VMT; everyone I know who is age 35 to 40 in New York City is moving to Astoria, Queens. VMT is driven by available housing, and there could be a decline in VMT because of available housing. In developing countries, for instance, in India, there is a demand for suburbs.

Overmyer: In Latin America there is an emerging middle class that prefers to live in private neighborhoods in the suburbs as a symbol of higher status, particularly in Buenos Aires and Rio de Janeiro.

Circella: I agree, in much of Latin America private suburban neighborhoods are seen as a status symbol.

Clewlow: Education is an important facet of this discussion. Schools drive housing choices and that the majority of schools in the suburbs are of higher quality.

Circella: There is a conflict between personal attributes and costs. Can we say that attitudes somehow cannot really express themselves because of cost limitations? Is this a main factor in travel demand? Sometimes there is a difference between attitudes and actions. For instance, if the cost of organic food is cost prohibitive, will people still buy it?

Overmyer: There is a mismatch between attitudes and values. For instance, purchasing the most recent iPhone every time it is released is not environmentally friendly. We still live in a consumerist society that has been greenwashed with diluted versions of sustainability. For instance, purchasing something that is "green" like a Prius is not environmentally sustainable if you already own a car. This only results in greater car ownership and not very impactful environmental benefits.

Jacob Kronbak: There is much more social equity in Denmark, and urban planning is deliberately conducted around noncar transportation. Furthermore, travel demand is determined largely by time constraints, i.e., an aversion to long commute times. Bicycling is very common, gasoline is more expensive, and automobile purchases are taxed 180%. This creates a climate that is more hospitable to alternative transportation modes.

Circella: In the United States, there have been studies that find a relationship between increased ridership and Wi-Fi service, even if it results in rising fares.

Mette Dyrberg: Families with children desire to live in city centers until their children age. This results in high demand which creates higher market rate rental prices. This makes housing options more difficult for students, but the city ensures that there is a supply of low- and middle-income housing. This is why effective policymaking is important.

Jacob Kronbak: The structure of the city of Copenhagen is also very different. It is small, dense, and has historically been mixed income.

Circella: What are developers doing in regards to affordable housing? How will this change travel demand and can the planning community align these planning processes?

David [Greene or Proffitt]: The land use planning process in the United States has shaped the transportation planning process and there is strong evidence that urban housing in the United States is undersupplied. Can transportation planning be based on the European model? For mixed-use developments the profit margins may be smaller, and the developments may take longer. Also, planning is done at the municipal level.

Circella: Who pays for transportation infrastructure? It is a huge problem in the United States.

Greene: The motor fuel tax should become an energy efficiency tax. That will encourage people to buy more-efficient vehicles. Replicating the Danish social and transportation system is nearly impossible in the United States, particularly the 180% tax on vehicles and American's lack of willingness to accept this level of regulation. American society does not seem to value this form of equity.

Kronbak: There are significant cultural differences between Denmark and the United States, however, in Denmark, people view regulation as an important necessity because they see it as a shared goal within a strong framework. In Denmark, they do have fairly strict building and zoning regulations and within these regulations, municipalities carry out collaborations and partnerships with developers.

Greene: Do regulations, such as requirements to promote bicycles, have cost–benefit analyses? Or is it just done because it is seen as a good thing?

Kronbak: I do not think that they do cost–benefit analysis for bikes. Bikes are generally seen as a responsible modal choice. There is strong political will and advocacy for bicycling and the municipality supports that will.

Adams: David brought up a good point when he said, "internalize the external costs and see who pays." If the United States approached transportation planning that way, the United States would experience significant results because drivers would understand the additional costs embedded within our transportation systems.

Greene: I do not think the United States will ever embrace a 180% tax on automobiles. This policy is at odds with American culture.

Adams: Costs are not internalized in the transportation system at all.

John Davies: Americans do not internalize any external costs. However, we have been able to do some pretty incredible things in the last few decades. For example, the redevelopment of the Navy Yards in the District of Columbia lead to the area having some of the highest rents in the

region. However, there has been very minimal investment in transportation. Efficient land use planning is helpful and while it is not the only way to use policy as a tool, it is still a potent one. the District of Columbia has historically had notoriously bad schools, but recently there have been more high-income families sending their kids to public school, in part due to a rise in popularity of charter schools. Small interventions can help accomplish big tasks.

Greene: A lot of the successes in the District of Columbia can be attributed to a successful metro system, particularly with high density development clustered along metro lines. Part of the problem in the United States is making public investments with a long-term vision. Internalizing external costs cannot create this circumstance. One must also take large investment risks to lead to greater livability.

Davies: A well-established metro system has contributed to the District of Columbia's new development. Furthermore, this renaissance of the downtown was largely anchored by the Verizon Center. However, there are certain low-cost investments that can make big differences.

Circella: The Atlanta metro system may be the only one in the country that doesn't receive any state funding due to political reasons. How could we possibly try to emulate Denmark when political issues are so difficult?

Kronbak: In Denmark, there was resistance to developing on Amager Island. The government accepted that they would go into debt in an attempt to develop this undeveloped tract. It was compared to putting a man on the moon and now it is considered to be a resounding success with new economic development and housing developments in the area. It is important to look beyond a cost–benefit analysis and look at the higher goal. But, one must be cautious of vanity projects with limited benefits.

Greene: Sustainability is not only about internalizing externalities, but envisioning the future and seeing if it is a good direction to go in.

Circella: There needs to be political willingness and it seems difficult that that would happen.

Lori Sundstrom: Political decision making is fragmented. There is an inherent incompatibility between the goals of local and state governments, particularly in the way that money flows to transportation and economic development. While the official position maintains that land use is a local issue, land use is still completely connected to state and nation. The majority of money flows to pavement and as long as that continues it will not go to other places.

Circella: I have seen that in California and Georgia. What should we expect in regard to the forces that are altering and affecting transportation? What role can technology play in the future?

Liange Gi: If there are 0.1% of driverless cars in the population, the overall impact will be neglibible. If there are 5% of driverless cars in the population, there will be a larger impact. Currently, much of the research now looks at a 100% driverless car scenario. In China, the main focus is economic growth. There is a high value placed on owning a car and buying an apartment as a young person with desirability associated closer to the core. This causes much congestion

due to the demand for these services and amenities within the core. China should emulate Singapore, where there are limited highways and cars are taxed highly so their infrastructure is used more efficiently. People that are rich and affluent are apathetic to issues of congestion because they have chauffeurs.

Greene: China has an important automobile industry so they cannot tax cars too heavily if economic growth is their priority.

Jaffe: There has been some progress shown because there have been some taxes on more "gas guzzling" vehicles in China.

Greene: It is important that researchers explain the benefits of pollution limitations, but there also needs to be research on large-scale projects, such as the subway in Denmark—projects that are created even when they do not seem to make clear economic sense over time. The job of researchers is to explain to people how and why things works and tell people why this is a sustainable and reasonable choice.

BREAKOUT GROUP D

Role of Government Policies Versus Private Initiatives in Leading the Future

APRIL MARCHESE
Federal Highway Administration, presiding

Dan Sperling, the keynote speaker, highlighted the importance of freight in his opening speech yesterday. However, it must be noted that no stakeholders from trucking, rail, logistics, supply chains, or the private sector were present. The private sector is typically not interested in public policy and sharing their information and data. In the EU, the private sector typically participates in this form of a conference, but will normally not share data. Mexico has a national logistics plan that has been developed in conjunction with the IDB.

To address gaps in knowledge concerning this circumstance, research questions can include best practices for data mining from the private sector and ways in which the government can approach the private sector to incentivize participation in goal accomplishment. This requires clarity regarding the intention of such collaboration and partnerships, particularly when interrogating the respective roles of the government and the private sector in utilizing "transportation in service of a more sustainable society." In the EU, many projects are initiated by the government in a more top-down approach, but there is also room for more bottom-up activity as well, particularly when the industry in question anticipates an opportunity for profit. While bottom-up efforts require support from the government, top-down efforts require participation from private-sector industry. Negotiating this relationship can result in a convergence of the public and the private.

In regards to airports, airports are designed as mini-cities that connect various systems. There has been an early momentum in airport sustainability that came from a CEO mandate to airport staff. During this momentum, sustainability actions characterized as low hanging fruit have been identified and achieved. The Airport Cooperative Research Program has conducted an extensive amount of research on aviation and sustainability and the FAA has invested significant funds in airport sustainability planning. However, further research needs must be addressed, particularly in understanding where multimodal coordination is needed, how cooperative research programs can achieve better crossmodal research, and gaining access to private-sector capital. Furthermore, an analysis of the span of control and governance of airports in comparison to airlines could bring forth interesting research questions regarding fuels, ground-support equipment, and the most efficient configuration of the movement of people and goods. Time is a pressing issue: many of these research topics will require small pilot projects, but in reality climate changes are too rapid to allow for these types of timelines. The question then becomes how to create a sense of urgency to catalyze more rapid progress through partnerships and parties who assume differing levels of risk.

Analyzing international experiences in regards to these queries can yield valuable insight. On an international scale, governments can function as "regulatory" or "catalytic," particularly in regards to creating venues for the private sector to innovate while fostering dialogues between vertical and multimodal typologies of business. The government can allow for private-sector consensus, but if that cannot be achieved they can be in a position in which they are prepared to

regulate. However, more research is needed to determine how a government can assume this more catalytic role.

The EU will commission studies from time to time to assess their transportation policies. Such studies include an EG on transport policies for GHG reduction that included a spectrum of measures ranging from deploy infrastructure, fiscal incentives, removal of bureaucracies, research, and development funding to a harmonization of policies. In 1997, there was a matrix within an EU report that identified all the different stakeholders involved in different multimodal activities. The question then becomes how to continue and sustain dialogue about how to internalize external costs for greater transportation efficiency.

In Paraguay, they initiated a public–private partnership (PPP) law (concessions, new roads), but did not have adequate human or financial resources to fully implement this law. The public sector must institute management tools for the private sector in order to define what is truly sustainable. The public sector is attempting to deploy INVEST to begin a process in which they attempt to attract large construction firms for public works and rely upon the private sector to drive progress on standards for sustainability during the bidding process.

Neil Pedersen: A summary of the government's role should include regulatory, incentives, education, partnerships and enabler. Automated vehicles are a key feature to a sustainable future. At first, Google was concerned about the government not being agile enough to keep up with advancements in technology, but now they are concerned that regulations may inhibit technological progress. The government should focus on enabling, not inhibiting progress in its regulatory role. The FHWA has a large influence over how to leverage distributed funds. This can allow for opportunities to incorporate sustainability in funding decisions. If sustainability was a larger factor in grants like TIGER grants, then state DOTs would have a greater need for sustainability-related research through NCHRP. TRB should be more future oriented, with sustainability as a key future issue for research and the annual meeting. How do we use regulatory frameworks to incentivize and enable, rather than inhibit progress? How do we use funding mechanisms to incentivize sustainability practices? How can we use tax policy to incent private sector to move in the directions we want to see with regards to sustainability (e.g., Norway has incredibly high vehicle taxes, but they have been eliminated for EVs).

In regard to performance measures being utilized to determine funding allocations, this form of distribution can have unintended consequences. For example, if some states fall short in their performances, it could indicate that they need more funding to accomplish these goals and should not be penalized with less funding.

Another sentiment included whether it would be appropriate to ask all TRB committees to articulate how their research agendas help move towards a transportation system that supports a sustainable society? This task could be a key outcome or action plan from the conference.

[Pedersen offered that this could be achieved by having sustainability proposed as a hot topic for TRB. Sustainability means so many different things to different people—a hot topic theme could help us dig into the details. This requires exploring the challenge of maintaining the high-level philosophical intent of sustainability versus operationalizing it at the environmental, social, and economic levels.]

Other questions can include the analysis of the sustainability impacts of PPPs. What are the outcomes of PPP processes and projects that make them more or less sustainable and in what ways? For instance, perhaps delivery time is shortened or budgets are reduced, but what about environmental or social outcomes? TRB is in a unique position to create a model for

interdisciplinary and multimodal coordination. Can TRB launch a multimodal project that fosters (or mandates) coordination across the silos? A long-term strategic plan for multimodal research requires first understanding how the currently siloed research is conducted. Certain transportation modes have coordinated in the past (i.e., NCHRP and TCRP), but these research agendas must be driven by the practitioners during these collaborations.

The essential role of government is to address market failures at the least amount of cost, as well as addressing social inequity. If we have a rule-based approach to sustainability, they must be robust and comprehensive rules. One research question in relation to this is how to conduct analyses to inform best policy approaches, primarily because cost analysis for projects is difficult and expensive. A main point of inquiry can be surrounding how to "operationalize" sustainability, which can have numerous downsides. However, climate change can be a big enough issue to justify such actions.

Other such "rapid fire" research ideas and questions can include: how to best utilize pricing to be used in conjunction to value? What's the value of a paratransit ride? What's the optimal measure to employ towards sustainability? How can we attract private organizations to invest in public infrastructure? How do explicit prices on an issue (e.g., carbon) compare to the effective price of a non-priced measure? If California runs out of water, what else matters?

In regards to an urban–rural divide, what's the role of transportation in sustaining the urban landscape? How do we value transportation's role in sustaining cities? How can we measure how unsustainable sprawl is? How can we leverage bicycles in cities where their use is appropriate? How do we predict where people will be living in the "new climate" future and transportation impacts?

In regards to technology and data privacy issues, what data is needed to have a more sustainable system? How can one conduct consensus building on values around use of new forms of transportation? How does regulation keep up with the pace of technology (e.g., with private ridership services like Uber and Lyft)? How can we measure how a law or regulation enables/inhibits sustainability? What's the role of transit agencies in a sharing economy? How do you plan TOD in a transportation sharing economy, particularly when jurisdiction issues can inhibit transit system efficiencies?

In regards to alternative fuels infrastructure, what is the effective role of government if business models "won't be profitable for at least a decade"? An analysis of an incentives only approach is required, as well as tax policy that standardizes infrastructure investment. Other areas of interest can be investigated under the category of metrics: how to broaden the dimension of indirect indicators in order to measure profitability and sustainability? How can government have a technologically neutral role? Can we make progress without picking a winner? Do we need to? Are current agency structures, governance, missions, and funding mechanisms adequate? New roles of government agencies may be needed.

Finally, how can we get TRB committees together to help work towards a new alternative fuels future? What are the best institutional practices for embedding sustainability? For slow moving and risk-averse agencies, particularly in the face of rapid climate change, social science catalysts are needed. Lastly, an evaluation of "soft" solutions (TDM, land use, and other noninfrastructure investments) is required when gauging their role in regards to big public works projects.

CLOSING PLENARY SESSION

The Way Forward

RALPH HALL
Virginia Polytechnic Institute, presiding

Hall introduced the Closing Plenary Session, which was a summary and discussion of the four working groups. One of the objectives of the conference was to create a research agenda for the Transportation and Sustainability Committee. He feels that a wide range of ideas were developed that can be used in the future. Hall is the chair of the Research Subcommittee of Transportation and Sustainability Committee, and he emphasized that an upcoming challenge is to have a formal research agenda by the next annual meeting.

Damon Fordham introduced some general themes that emerged from the conference:

- Climate change is an all-encompassing challenge that will drive sustainable transportation.
  - Should it be separated from sustainability because it is so important?
- Freight stakeholders may not have been well-represented.
- Transportation should be "in service of a sustainable society," rather than sustainable transportation as a single goal, so that sustainability has a broader definition involving equity.
- Should sustainability be a high-level philosophical concept? Or should it be operationalized? It's important to consider interconnections and systemic effects.
- TRB needs to promote more multimodal research and collaborate across silos. Great research has been done in the air transportation sector, and it could be applicable to other areas.
- Sometimes the progress we make is incremental and slow. Pilot projects and small increments may not be adequate to address the urgency of issues.
- Government can be a "catalyzer" for change, instead of just a "regulator."
- Automated vehicles can be a key to sustainability.
- More data is needed to inform decision making. We also need to consider how that data is collected, managed, and used.
- Sustainability could be proposed as a "hot topic" for TRB.

Ralph Hall represented Group A: Developing Countries—Challenges on the Path to Sustainability and presented additional themes.

- How might the post-2015 agenda impact efforts to advance sustainable transportation?
- How do we finance "sustainable" urbanization?
- How do we avoid the "lock-in effect" from investing in high-carbon-related transportation infrastructure?
- How can we "green" transportation metrics in developing countries and emerging economies?
- How do we leverage green TOD (particularly in China)?

- How do we balance advancing and constraining transportation options for sustainability?
- How do we address the gap between urban planners, transportation professionals, and other disciplines?
- How can we leverage new mobility options in developing countries?

FEEDBACK FROM GROUP A

Developing Countries: Challenges on the Path to Sustainability

- Main points:
  - The webcast technology worked well and should be used at the TRB Annual Meeting. It is especially useful for people who cannot afford to come to the Annual Meeting. It was also useful when everyone participating in the session was able to collaborate on the same Google document.
  - Develop frameworks for measuring, understanding, and achieving sustainability. Can we do a task force around this? How do you frame it?
  - We need to define and measure sustainable transportation.
  - Other issues and factors need to be considered (land use, housing, urban design), and we need to engage with experts in other fields.
- Research, education, and training:
  - Curriculums need to provide skills that are applicable to developing regions.
    - This could be achieved through courses that connect developed and developing countries. Students from different countries can work on the same problem. TRB could be a facilitator.
  - Support enhancement of professional training programs.
    - Look beyond TRB and model training after "Transforming Transportation." Apply the "flipped classroom" approach so that people can come in more knowledgeable of the issues.
    - Adjust standards of professional training around the world, and include sustainable transport.
  - Two-way learning is important for sharing best practices.
  - Collaboration with academics, nongovernmental organizations, governments, development banks, etc., is important.
- Research, the new paradigm:
  - What are the key factors at play in the paradigm shift toward sustainable transportation?

Steve Olmsted spoke on behalf of Group B: Practitioner's Guidance on Implementing Sustainability. In regards to what was mentioned earlier, the freight supply chain and freight mobility is an issue that is important to the Arizona DOT, and it is an initiative of the director. Olmsted mentioned that he is from a traditional state DOT and is familiar with the implementation side of transportation practice. He developed six questions to help identify gaps and needs to assist practitioners.

Four Themes Related to New and Mature National Transportation Systems

- Approaches to developing youth education and stakeholder outreach around sustainability.
  - If we educate the masses then they will be more informed stakeholders, and it's best to start with the youngest generations. Younger generations can be reached through social media.
- Continue altering the behavioral mindset.
  - There are opportunities for behavioral research around sustainable transportation and sustainable transportation initiatives.
  - It's important to consider how people think about sustainability within their own discipline, whether it's planning, construction, or something else.
- Identify three leading impediments to further implementation of sustainable transportation systems.
  - People and education:
    - At Arizona DOT, there have been efforts to reach out to MPOs, councils of government, universities, and the larger community.
  - Funding and prioritization of resources:
    - It is difficult to fund legacy systems, and then to add sustainability initiatives.
  - Sustainability is continually redefined.
    - We need a singular message that is applicable to the public and legislators. If sustainability is at the top of everyone's agenda, then it's more likely to be funded.
- Defining set sustainable transportation frameworks and expectations:
  - Financiers, stimulators, facilitators, and implementers need to be focused on a singular message.
  - Events like this conference are important developing messaging.
  - It is ever changing and things vary geographically, but there are things that can be singularly defined.
- Research needs:
  - There are tremendous constraints on funding various transportation modes. We need to identify how to balance funding for new modes, versus how to fund and manage legacy system deterioration.
  - Identify new and novel ways to change behavioral attitudes, and then find out what people want.
  - Develop balanced research to support the expectations of multiple stakeholders (financiers, stimulators, facilitators, and implementers) as they relate to new national transportation systems.

Giovanni Circella spoke on behalf of Group C: Factors Affecting Demand for Transportation and Impacts on Sustainability. Session C was not available for live webcast, so discussion was limited to people in the room.

- Mobility trends: VMT.
  - There has been a decrease in VMT in the United States and other countries.
    - This may be due to changing economic cycles.
    - But in 2015, travel demand seems to be increasing.

        - Are there temporary or permanent effects on travel demand?
- Mobility trends: urban form.
    - There has been significant growth in the central areas of many cities in the United States, and that growth has often been faster than in the suburbs.
    - Many young adults are moving to cities, and there is more mixed-use housing.
- Mobility trends: car- and ride-sharing (ZipCar, Uber).
- Reasoning behind VMT trends:
    - Traffic congestion leads to higher travel times.
    - Public transit is growing.
    - Urban sprawl is waning.
    - Policies promoting smart growth, TOD, and compact development.
    - A growth in urban lifestyles and culture.
    - A rise in fuel prices.
    - Economic cycles lead to life-cycle or lifestyle changes.
    - Travel demand may be decoupled from economic growth.
    - Aging of the population.
    - Generational changes in travel attitudes and behavior.
- Group discussion:
    - The regime supporting growth in travel demand is weakening.
        - The United States is reaching a saturation point of drivers licenses because almost everyone that can be is a licensed driver, partly because of more women driving.
        - But, in developing countries, there will likely still be growth in travel demand.
    - Much of the changes in travel demand are due to economic growth, income, urban form, and impacts of travel costs.
    - Impacts on travel demand:
        - Income growth has mainly been for higher income classes.
        - There is potentially a mismatch between personal attitudes–preferences, and behaviors.
        - There has been a lot of attention on millennials, but do they actually travel differently than the rest? If so, why? Different lifestyles and attitudes?
        - Impact of urban form: the role of developers (is there an undersupply of urban housing?) where residences are located, and federal, state, and local policies.
    - Europe versus the United States:
        - What is actually politically feasible?
        - How do you fund transportation infrastructure? How do you internalize costs?
    - Role of technology:
        - How is it impacting travel demand? Can technology change habits?
        - Will ride-sharing and car-sharing reduce car ownership and the amount of people driving alone? Could they help extend the range of public transportation?
        - What will the impact of autonomous vehicles be?

Damon Fordham spoke on behalf of Group D: Role of Government Policies versus Private Initiatives in Leading the Future.

- Potential research areas:

– A national logistics plan is needed because freight and logistics can play a role in sustainability.
– How can government actors play a more catalyzing role?
– How can agencies and organization better foster changing management needs?
– How can sustainability be incorporated more into funding decisions and formulae?
– Are the outcomes of PPPs more or less sustainable? In what ways?
– How can regulation keep up with the pace of technological change?
– How do you plan TOD in a transportation-sharing economy?
– Private-sector business models for alternative fuel infrastructure may not be profitable for at least a decade. There is a strong role for government in promoting alternative fuel vehicles and in working with the private sector.
– Are current transportation agency paradigms (mission, governance, funding, and organization) adequate for a sustainable future?

Ralph Hall: What themes and research needs were missed?

Henrik Gudmundsson: I think the statements on autonomous vehicles are too vague or passive. I am reluctant to believe they are the key to the sustainable future. From a sustainability point of view (social, economic, and environmental), what are the requirements necessary to implement autonomous vehicles? How can they be part of the solution instead of part of the problem?

Roger Venables: The title of the conference—Transportation for Sustainability—is very intriguing. What do we mean by transportation for sustainability? In CEEQUAL, they distinguish between whether or not the project is part of the transport system, a destination, or neither. What is the role of transport? What do we want it to be? What are the social questions we are asking ourselves? Should we ration luxury travel? But if we do, there could be negative impacts on economic development in certain areas. Demand management can be helpful at a world environmental impact level, but it can be counterintuitive in terms of sustainable development.

Hall: The issues you raise would be important to a taskforce on developing a sustainability framework.

Todd Litman: TRB should work with other organizations to develop standard datasets for sustainable transportation evaluation. To make progress, we need good information, "you can't manage what you don't measure." TRB should get involved in international transport intelligence efforts.

Antoniette Quagliata: How can we operate our transportation facilities and systems (buildings, fleets) more sustainably? What are some sustainable practices for the construction of infrastructure (methods, materials)?

Hall: Those are good points and TRB does have committees focused on structures and operations.

Comment from the web: We need to support the United States's movement to the metric system.

Comment from the web: How do we deal with legacy systems? Tear them down?

STUDENT POSTER SESSION AWARD REVIEW

Giovanni Circella: Having a poster here means the student has already reached a very high level of achievement. There were 16 posters, and one winner was selected. The selection process was based on the abstract, the digital copy of the report, and the actual poster. There were four major selection criteria: holistic view of sustainability; excellence of content; originality either in content, communication, or something specific within the research; and communication (written and in person). Congratulations to all the students for their submissions. It was particularly impressive that undergraduates submitted posters.

Joe Zietsman presented the award. He was impressed with the verbal communication skills of the students; they were very excited and knowledgeable about their topics. Furthermore, he encourages the students to submit their posters as papers to TRB.

Josh Defloria presented $500 to the winner on behalf of Cambridge Systematics.

Winning poster: Shaun Bortei-Doku, Mette Dyrberg, Yannick Cornet, and Marie Ridley Pryn, Teehnical University of Denmark, Kgs. Lyngby, Denmark. Honorable mention: Hamed Ahangari, University of Connecticut

April Marchese thanked everyone and introduced Neil Pederson, executive director of TRB.

Pedersen: I was encouraged by my predecessor to be selective about which workshops and conferences I attend, as there just is not enough time. I will attend only two conferences in 2015 for TRB, including this one, because the subject is so important. As transportation professionals, we have an obligation to be thinking about transportation and sustainability. TRB needs to focus on strategic, crosscutting, long-term issues. We probably have not done as good of a job addressing future strategic issues as we could. Our challenge is to take the knowledge that we gathered during the conference, and carry it out into the broader transportation community. In future strategic planning, each year a hot topic will be identified. A hot topic is a strategic issue, and identification of the issue could come from the bottom up. I challenge conference attendees to become ambassadors for sustainability within TRB and other places. Sustainability should be important to all TRB committees, not just the Sustainability Committee. We need to convert concepts that have been discussed into problem statements. We have to think strategically, but we also need to identify issues that need to be addressed within sustainability. Sustainable thinking means thinking decades into the future.

Pedersen then went on to thank the conference organizers, speakers, moderators, and sponsors. The format really encouraged dialogue. Pederson specifically thanked Monica Starnes and Brittney Gick of TRB. One-hundred people attended in person, representing 10 countries, and 325 attended through the webcast, representing eight countries. Pederson emphasized that he

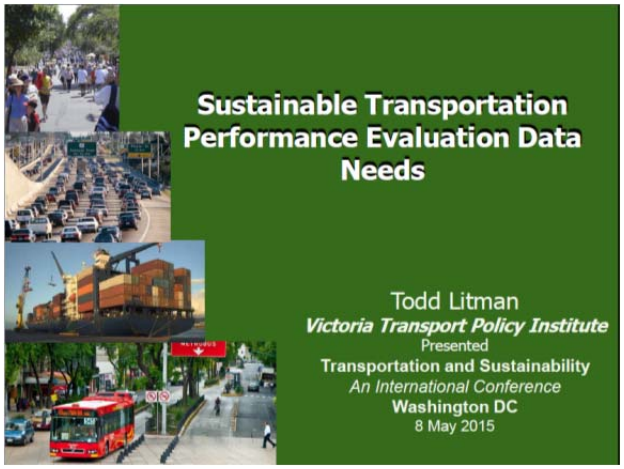
has benefitted greatly over the years from international dialogue.

Zietsman encouraged everyone to become a friend of the sustainability committee. **Marchese** gave the final thanks and adjourned the conference.

APPENDIX A

PDF Presentations

SUSTAINABLE TRANSPORTATION PERFORMANCE EVALUATION DATA NEEDS
Todd Litman, Victoria Transport Policy Institute



What Information Do We Need?

- What type of transport system will be needed in the future?
- What planning is needed to create that system?
- What information do we need to support that planning?
- How well are we doing collecting that information?

Demographics
Income and employment
Vehicle ownership
Vehicle operating costs and fares
Road and parking fees
Freight transport demands
Travel conditions
Land use development
New technologies
Consumer preferences
Safety and health impacts
Environmental impacts

Defining Terms

- **Data** (also called **statistics**) refers to specific information reported without context, such as vehicle-miles-traveled (VMT), traffic speeds, and traffic fatalities.
- **Information** is organized and comparable, and therefore suitable for research, such as statistical analysis of relationships between VMT, traffic speeds and traffic fatalities.
- **Knowledge** is abstract, organized and transferable, and therefore suitable for decision-making, such as a functional model that can predict how specific transport policy and planning decisions will affect traffic accident risk.
- **Wisdom** is the ability to understanding and apply knowledge. It considers context and values, such as a decision-makers ability to determine what transport policy and planning decisions are optimal, balancing accident risk against other planning objectives, and reflecting a community's needs and values.

Wisdom requires knowledge, which requires information, which requires data. Quality data and analysis are essential for good decision-making.

Data Types

Inputs	Outputs	Outcomes
What is put into the system	Direct results	Ultimate results
• Vehicle ownership • Road supply and design • Public transit supply and service quality • Urban design (density, mix, etc.) • Government expenditures	• Vehicle travel • Walking, cycling, public transit travel • Mode share • Fuel & energy consumption • Consumer expenditures	• Accessibility (people's ability to reach desired services and activities) • Affordability (portion of household budgets devoted to transport) • Per capita government expenditures • Health, death rates • Portion of land used for transport facilities

Defining Data Quality

- **Accuracy.** The methods used to collect statistics must be suitably accurate.
- **Transparency.** The methods used to collect statistics must be accessible for review.
- **Comprehensiveness.** An adequate range of statistics should be collected to allow various types of analysis.
- **Frequency.** Data should be collected regularly.
- **Consistency.** The range of statistics, definitions and collection methodologies should be consistent.
- **Availability.** Statistics should be available to users.

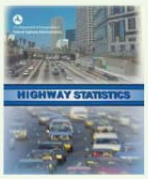
Basic Data Sets

Supply	Activity	Economics	Impacts
Roads (supply and quality, including congestion delays) Sidewalks and paths (supply and condition) Railroads (supply and quality) Transit services (supply and quality) Airports Ports Vehicle ownership (by type)	Vehicle travel (by vehicle type) Personal vehicle travel (by trip type, demographics, location) Non-motorized travel activity (by distance and time) Mode split (by trip type, demographics, location) Freight transport (by mode, type, location)	Fuel prices Public transportation fares Government expenditures on transport facilities and services Consumer expenditures on vehicles and transport services	Crashes and casualties Energy consumption Air and noise pollution emissions Land use factors (land devoted to transport facilities, density, mix)

Existing Data Sources

International	Europe	North America
International Road Federation	European Union Energy and Transport in Figures	Bureau of Transportation Statistics
Millennium Cities and Mobility In Cities Database	European Commission	Highway Statistics
EarthTrends Searchable Database	European Conference of Ministers of Transport	Census Bureau
OECD Transport Statistics	European Environment Agency	National Household Travel Survey
World Bank	Transport Statistics Great Britain	Department of Energy
		Statistics Canada
		Transport Canada

Data Sources




Sustainable Planning

Sustainability emphasizes the integrated nature of human activities and therefore the need to coordinate planning among different sectors, jurisdictions and groups.

4/23/2015

Changing Paradigm

	Old Paradigm	New Paradigm
Definition of Transportation	**Mobility:** movement of people and goods	**Accessibility:** ability to access goods, services and activities
Planning objectives	Maximize mobility, minimize time and monetary costs	Maximize accessibility, cost efficiency and user options. Respond to consumer demands.
Impacts considered	Travel time, vehicle operating costs, risk, and some pollution emissions	Total benefits and costs, including various external, indirect and non-market economic, social and environmental impacts.
Options considered	Primarily road and parking facility improvements, and major transit improvements on some urban corridors.	Multiple modes (walking, cycling, ridesharing, automobile, public transit, and telework) and demand management strategies (road space prioritization, pricing reforms, smart growth land use policies).
Consideration of travel demands	Focuses primarily on automobile travel demand. Seldom applies transportation demand management.	Considers demand for all modes, including latent demands. Often considers transportation demand management solutions.
Performance indicators	Vehicle travel speeds, vehicle operating cost per person-km, roadway level-of-service	*Accessibility:* number of opportunities people can reach within a given time and money budget. Service quality of various modes.
Favored improvements	Projects that increase motor vehicle travel speeds.	Policies and projects that increase transport system efficiency and diversity.

Data Availability

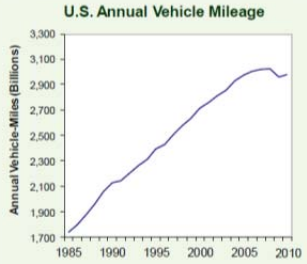
Generally Available

- Transport facility supply
- Vehicle supply
- Public transport supply
- Motor vehicle traffic conditions
- Crashes
- Pollution emissions

Often Unavailable

- Parking facility supply
- Non-motorized transport conditions and activity
- Total transport expenditures
- Land use factors
- Disaggregated crash rates
- Detailed pollution emissions
- Economic impact factors

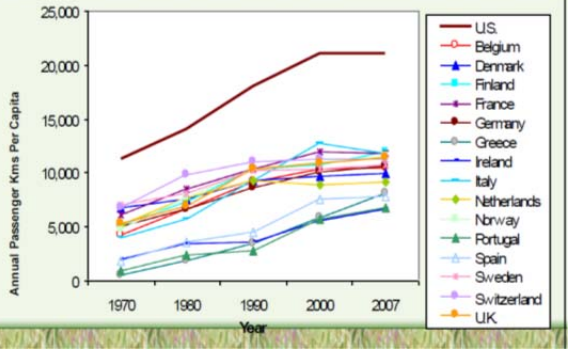
Changing Travel Demands

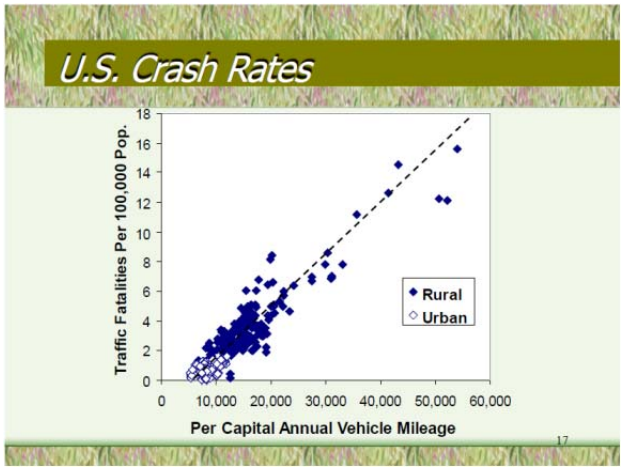


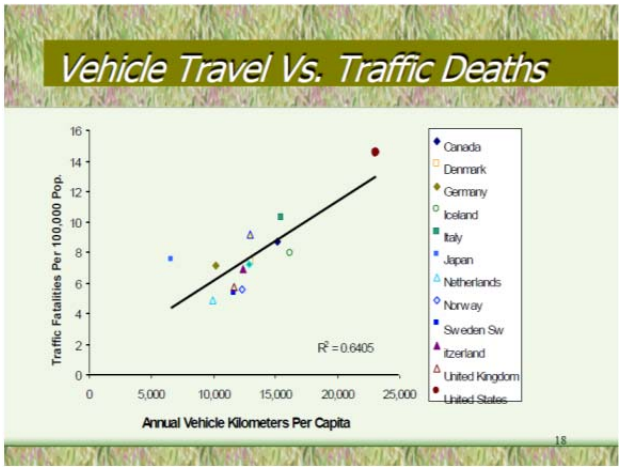
U.S. vehicle travel grew steadily during the Twentieth Century but stopped about 2003.

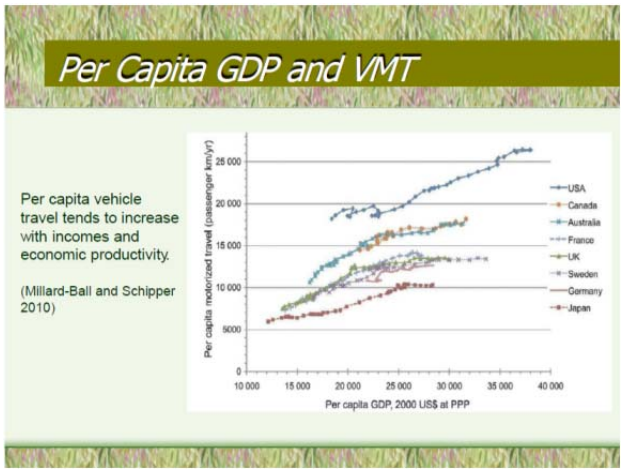
- Motor vehicle saturation.
- Wealth effect
- Aging population.
- Rising fuel prices.
- Increased urbanization.
- Increased traffic and parking congestion.
- Rising roadway construction costs and declining economic return from increased roadway capacity.
- Environmental concerns.
- Health Concerns

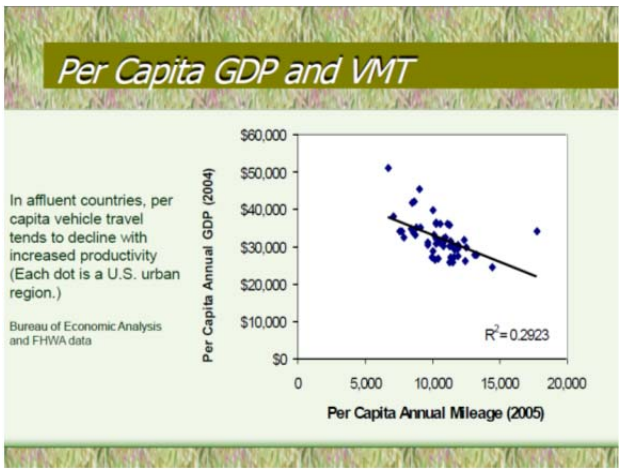
International Trends











Emerging Issue	Performance Indicators	Data Required	Current Availability
Quality of alternative modes (walking, cycling, public transit)	Multi-modal level-of-service indicators	Detailed GIS data on walking and cycling conditions, road traffic conditions, transit service availability and quality, and land use factors	Most jurisdictions collect some of this information but there is little consistency which will make it difficult to compare jurisdictions.
Multi-facetted accessibility	Transport network connectivity and land use factors. Quality of mobility substitutes such as telecommunications and delivery services.	Multi-modal travel speed and affordability. Detailed land use development (density and mix) and transport network connectivity data, and therefore travel distances to various activities and services.	Some information is available through Census and similar data sets, and road network connectivity data is usually available, but comprehensive transport network connectivity data are often incomplete.
Transportation affordability	Portion of household budgets devoted to transport, particularly for lower-income households.	Fine-grained household expenditure data (disaggregated by demographic, geographic and transportation factors)	Some aggregate data are available from the BLS Consumer Expenditure Survey.
Mobility for non-drivers	Quality of non-automobile travel options (walking, cycling, public transit, etc.), and cost burdens of mobility disadvantaged groups.	Detailed data on travel activity by various disadvantaged groups (youths, seniors, people with disabilities and low incomes, immigrants and tourists), and the quality of non-auto travel options	Some data is available, but it is often not comprehensive or consistent.
Social equity	The distribution of transport costs and benefits, and the quality of transport options for disadvantaged groups.	Fine-grained data on the distribution of various transport costs and benefits, and the quality of transport options for disadvantaged groups.	Some data is available, but it is seldom comprehensive or consistent.

Emerging Issue	Performance Indicators	Data Required	Current Availability
Comprehensive cost analysis	Various economic and environmental costs	Fine-grained data on the costs of vehicles, facilities, accidents, travel time, congestion, pollution emissions, etc.	Some data are available, but not consistent. Much of the research is old and outdated.
Vehicle parking	Vehicle parking demands and costs.	Detailed data on vehicle parking supply, utilization, costs, prices, demand, and impacts.	Some data are available from special surveys and studies, but not comprehensive or consistent.
Local economic impacts	Transport planning decision impacts on employment, incomes, business activity, property development, property values, tax revenues, etc.	Detailed data on various economic conditions and impacts, including commercial street development. Again, the "delta" is what is interesting.	Some data are available from national sources but it is seldom comprehensive or consistent.
Indirect environmental impacts	Transport impacts on resource consumption, hydrologic effects, habitat and species invasions.	Detailed data on energy and other resource consumption, impervious surface and hydrologic effects, habitat area and connectivity, and alien species dispersion.	Some data are available from special studies, but not comprehensive or consistent.
Impacts on strategic development objectives	Transport planning decision impacts on land use development patterns, density and mix.	Detailed data on development density and mix.	Some data are available from various sources.
Public fitness and health	Active travel (walking and cycling) activity and conditions, body weight.	Fine-grained data on walking and cycling mode share, travel distance (miles) and time (daily minutes) and conditions (walking and cycling facilities).	Newer travel surveys are collecting more detailed information on active mode travel, but it is still incomplete.

Data Problems

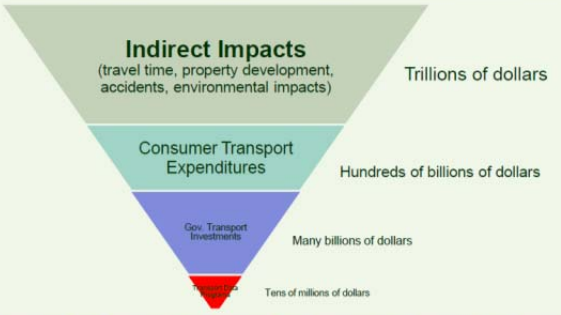
- Statistics are often incomplete, consisting of a limited set of information needed for analysis and planning.
- Some statistics are of questionable accuracy, based on inadequate methods or sample size.
- Transportation decision-making is skewed in favor of easy-to-measure impacts at the expense of more-difficult-to-measure impacts.
- Statistics are incompatible between different agencies, jurisdictions and time periods, making it very difficult to compare conditions, evaluate relationships and track trends.
- Statistics that do exist are often unavailable except to a limited audience, or they are made available in a format that is difficult to work with.
- There is seldom independent review and reporting of data quality.

Threats

We face a real possibility that the quality of basic transport-related data may decline in the future due to U.S. and Canadian federal policy decisions.

- Reduced Census long-form
- Lack of coordination between different jurisdictions (cities, states, countries) and sectors (transport, land use, health, etc.)
- Lack of appreciation by decision-makers

Data Program Costs in Perspective



Information Resources

Australian Transportation Data Action Network (www.nss.gov.au/transportmetadata)

CitiesACT (www.citiesact.org), online database providing access to transport, energy and emission data for Asian countries, by the Clean Air Initiative for Asian Cities (CAI-Asia).

Global Transport Intelligence Initiative (www.slocat.net/key-slocat-prog/466) is collaboration by international organizations involved in trasport data collection, analysis and dissemination.

Todd Litman (2007), "***Developing Indicators For Comprehensive And Sustainable Transport Planning***," *Transportation Research Record 2017* (www.vtpi.org/sus_tran_ind.pdf).

FHWA Highway Statistics (www.fhwa.dot.gov/policyinformation/statistics.cfm)

OECD Transport Statistics (www.oecd.org)

Sustainable Transportation Indicators: A Recommended Program To Define A Standard Set of Indicators For Sustainable Transportation Planning, Sustainable Transportation Indicators Subcommittee (ADD40 [1]), TRB; at www.vtpi.org/sustain/sti.pdf.

How We Travel: A Sustainable National Program for Travel Data, Special Report 304, Transportation Research Board (http://onlinepubs.trb.org/onlinepubs/sr/sr304.pdf).

Conclusions

- Various types of data are critical for effective transport policy making, planning, performance evaluation and research. New planning issues expand their scope.
- Different players have very different perspectives concerning the data scope and priorities. Strategic planning requires comprehensive consideration of these needs.
- Transport-related data are collected by many organizations, but results are sometimes not comparable or useful for research due to inconsistent definitions and collection methods. Strategic coordination can increase data program efficiency.
- North American transport data programs are poorly coordinated with the International efforts to develop more consistent data collection definitions and methods.
- Some current data programs are under threat. In the future we may have less information on travel activity than we had in the past.
- The transportation profession lacks leadership for strategic data programs. Some organizations that should be promoting data program improvements are prohibited from lobbying (TAC and TRB).
- There is a need for transportation professionals to better communicate the value of high quality data, and support more strategic data program planning and development.

"Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications"
"Valuing and Improving Transport-Related Data Programs: 2013 TRB Sessions"
"Developing Indicators For Comprehensive And Sustainable Transport Planning"
"Transportation Affordability: Evaluation and Improvement Strategies"
"Toward More Comprehensive and Multi-modal Transport Evaluation"
Measuring Transportation: Traffic, Mobility and Accessibility
"Online TDM Encyclopedia"
and more...

www.vtpi.org

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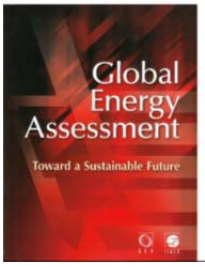
ROLE OF ZERO EMISSION VEHICLE MANDATES IN THE TRANSITION TO SUSTAINABLE ENERGY FOR MOTOR VEHICLES

David L. Greene and Sangsoo Park, University of Tennessee, and
Changzheng Liu, Oak Ridge National Laboratory

The Role of Zero Emission Vehicle Mandates in the Transition to Sustainable Energy for Motor Vehicles

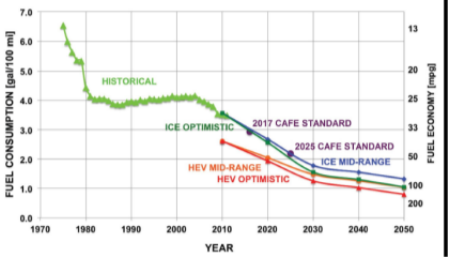
David L. Greene & Sangsoo Park
University of Tennessee
Changzheng Liu
Oak Ridge National Laboratory
Transportation for Sustainability
Keck Center, Washington, DC
May 6 – May 8, 2015

Sustainability appears to require an energy transition and that poses a novel challenge for public policy.

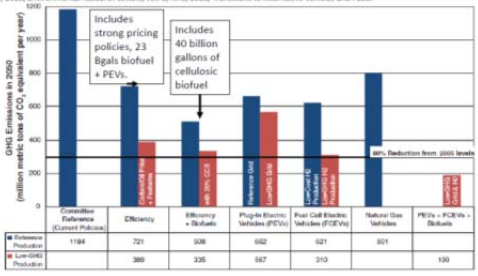


- *"Without question a radical transformation of the present energy system will be required over the coming decades." (p. xiii)*
- *"An effective transformation requires immediate action." (p. xv)*
- *"In all (sustainable, ed.) pathways conventional oil is essentially phased out shortly after 2050." (p. 51)*
- (IIASA, Global Energy Assessment, 2012)

Energy efficiency is the #1 strategy for reducing GHG emissions from transportation. But even tripling MPG is not enough.



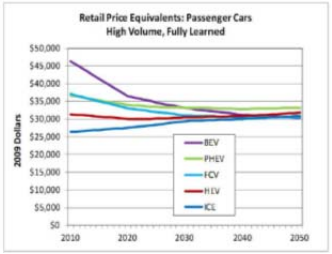
The NRC *Transitions* study (and others) showed that an 80% reduction from 2005 GHG emissions for light-duty vehicles by 2050 will require a transition to zero tailpipe emissions, electric drive vehicles.
Wei et al., 2013, Environmental Research Letters, vol. 8; NRC, 2013, *Transitions to Alternative Vehicles and Fuels*.



How are we going to do that?

- Vehicles with the potential for nearly zero lifecycle GHG emissions appear to be required to reduce car and light truck emissions by approximately 80% over 2005 levels by 2050.
- For the transition to be cost-effective we must achieve technological advances, learning & economies of scale on the supply side.
- Barriers such as lack of refueling infrastructure, resistance to novel technology, and lack of diversity of choice must be overcome, as well.
- Due to the long time constants for change, policies must begin now and must cope with profound uncertainty.

The NRC *Transitions* report's technology assessment found that by reducing vehicles' power requirements via reductions in mass, aerodynamic drag and rolling resistance, efficiency improvements help make e-drive vehicles **cheaper** than ICEs after 2040.



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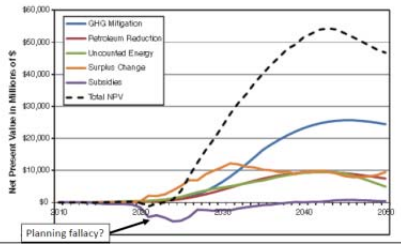
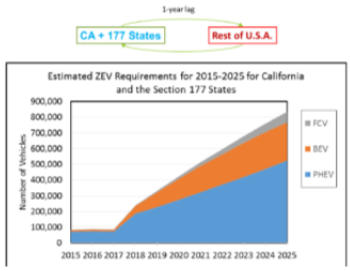
The NRC's *Transitions to Alternative Vehicles and Fuels* presents a **cost/benefit analysis of the transition** for light-duty vehicles. ***Estimated*** *benefits exceeded costs by an order of magnitude.*

Transition Costs and Benefits (2009 $): U.S. Light-duty Vehicles



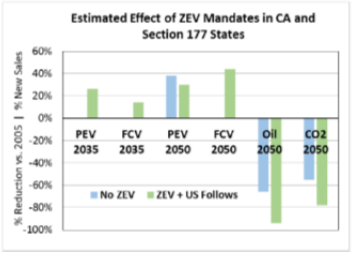
The NRC Transitions model was used to analyze the impacts of the ZEV mandates. Two regions were created to study the interaction between California + 177 States and the Rest of the US.



The "No ZEV" case assumed major policy changes.

- GHG emission/fuel economy standards are continually tightened
  - To about 75 MPG by 2050 (test cycle MPG)
  - Induces "feebate like" vehicle pricing by manufacturers
- Motor fuel tax converted to an energy tax
  - Indexed to average MPG of all vehicles in use and inflation
  - Reaches almost $1.50/gallon by 2050
- NRC Committee's assumptions about expected technological progress.
- No ZEV Mandates, federal and state subsidies for alternative fuel vehicles end after 2015.
- 23 billion gallons of low-GHG cellulosic ("drop in") biofuel by 2050.

Without ZEV or incentives for alternative vehicles and fuels after 2015, BEV and PHEV sales die out but BEV sales recover after 2040. No fuel cell vehicles are sold.



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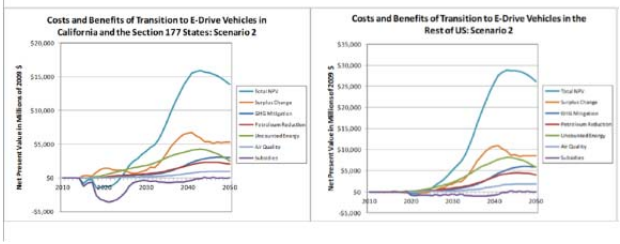
In the ZEV Case, the Rest of US adopts CA policies 5 years later.
By leading, California + ZEV states assume a greater initial burden and provide spillover benefits to the rest of the U.S.



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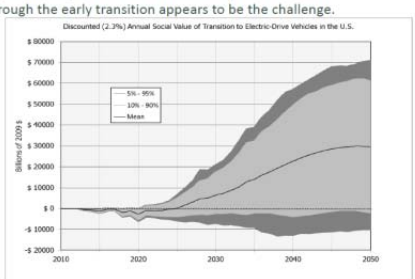
There is a lot that we don't understand well at present. Research could reduce uncertainty and save money.

1. Innovators/majority: How many? How much will they pay? For how long?
2. How important is fuel availability?
3. How important is limited range/long recharging time?
4. How valuable are workplace & public recharging?
5. How valuable is the diversity of vehicle choices?
6. How big are scale economies?
7. What will future technology costs be and how will they be affected by learning by doing?
8. How important is coordination with the rest of the world?
9. How sensitive are consumers' choices to vehicle and fuel prices?
10. What are viable financing policies & business models for early recharging and refueling infrastructure?
11. Which policies are most cost-effective and acceptable?

13

Even considering both technological and market uncertainties expected excess costs (subsidies) seem likely to be small relative to expected benefits.
Getting through the early transition appears to be the challenge.



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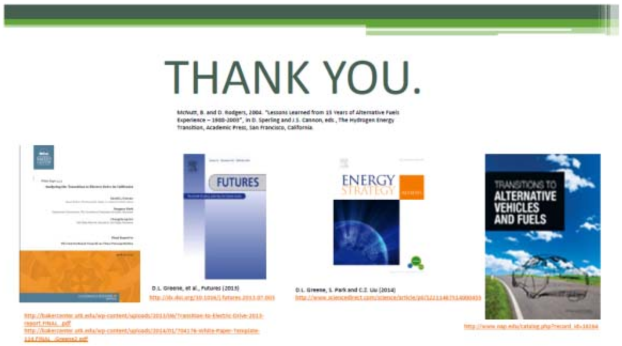
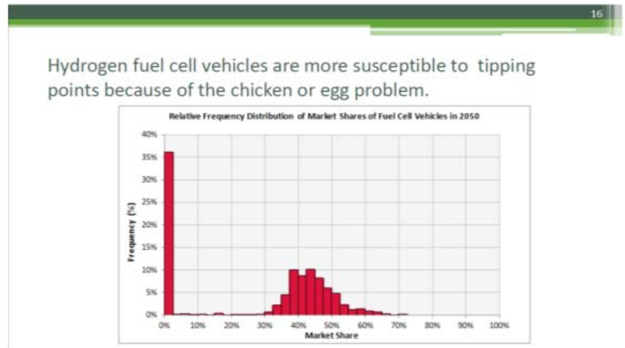
Accomplishing an energy transition for the public good is a new problem for public policy.

- It takes decades. The difference between social and private discount rates becomes critical.
- It requires technological progress which is inherently uncertain.
- Externalities are involved but not all the social costs are externalities (e.g., monopoly power in world oil market).
- There are other important market inefficiencies (e.g., energy paradox).
- The transition creates external benefits which are difficult for private agents to capture.
  - Reduction of risk-aversion of majority via cumulative sales (Direct Network External Benefit)
  - Value of fuel availability to car buyers (Indirect NEB)
  - Learning-by-doing spillover
  - Value of choice diversity (versus scale economies)
- External benefits and positive feedbacks (scale economies, LBD) are powerful, creating tipping points.
- What future will we create?


THANK YOU.
McNutt, B. and D. Rodgers, 2004. "Lessons Learned from 15 Years of Alternative Fuels Experience – 1988-2003", in D. Sperling and J.S. Cannon, eds., The Hydrogen Energy Transition, Academic Press, San Francisco, California.
FUTURES
ENERGY STRATEGY
TRANSITIONS TO ALTERNATIVE VEHICLES AND FUELS
D.L. Greene, et al., Futures (2013)
D.L. Greene, S. Park and C.Z. Liu (2014)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Hydrogen fuel cell vehicles are more susceptible to tipping points because of the chicken or egg problem.
Relative Frequency Distribution of Market Shares of Fuel Cell Vehicles in 2050
Frequency (%)
40%
35%
30%
25%
20%
15%
10%
5%
0%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Market Share

APPENDIX B

Final Program

THURSDAY, MAY 6

8:30 a.m.–4:00 p.m., *Keck 100 Lobby*
Registration

8:30 a.m.–9:30 a.m., *Keck 100 Lobby*
Breakfast

9:30 a.m.–10:30 a.m., *Keck 100*
Opening Session: Setting the Stage
April Marchese, Director, Office of Natural Environment, Federal Highway Administration (FHWA), *presiding*

Welcome Address
Neil Pedersen, Executive Director, Transportation Research Board
Joe Zietsman, Environment and Air Quality Division Head, Texas A&M Transportation Institute (TTI)

Keynote Talks to Set the Stage
Dan Sperling, Distinguished Professor and Founding Director, Institute of Transportation Studies, University of California (UC), Davis

10:30 a.m.–11:00 a.m.
Break

11:00 a.m.–12:30 p.m., *Keck 100*
Plenary Session: Global Initiatives
Henrik Gudmundsson, *presiding*

A session to discuss sustainability and sustainable transportation in the context of global initiatives and also to provide the perspective of developed as well as developing nations.

Holger Dalkmann, Director, Strategy and Global Policy, EMBARQ Director, WRI Ross Center for Sustainable Cities; Jose Luis Irigoyen, Director, Transport and ICT Global Practice, World Bank; Shoshana Lew, Deputy Assistant Secretary for Transportation Policy, U.S. Department of Transportation (DOT)

12:30 p.m.–1:45 p.m., *Keck 100 Lobby*
Lunch

1:45 p.m.–3:15 p.m.
Breakout Sessions

Breakout 1: Assessing Solutions for Common Sustainability Problems, *Keck 100*

Shannon Eggleston, American Association of State Highway and Transportation Officials, *presiding*

Many countries have common issues related to sustainability and transportation. This session will showcase state-of-the-art solutions applied in the United States and other countries and methods for assessing the performance of these solutions. Hear examples of how bus rapid transit (BRT), affordable housing, climate mitigation, and urban development strategies are improving sustainability in three continents. Discuss with researchers and practitioners how these solutions may be applicable elsewhere and how to assess their performance.

Social, Environmental, and Economic Benefits of Bus Rapid Transit: Case Studies from Colombia, Mexico, South Africa, and Turkey
Juan Velasquez, EMBARQ

Developing an Assessment Model for Site Selection of Affordable Housing Communities in Rail Transit Corridor of Kaohsiung, Taiwan
Kang-Li Wu, Harbin Institute of Technology

Evaluation of MTC's Climate Initiatives Program
Stephanie Hom and Ursula Vogler, Metropolitan Transportation Commission (MTC), and Jeffrey Ang- Olsen, ICF International

Low-Emission Urban Development: A Critical Analysis of Residential Neighborhoods in Delhi, India
Amit Arora, School of Planning and Architecture, New Delhi

Breakout 2: Institutionalizing Sustainable Practices Globally, *Keck 101*

Arturo Ardila-Gomez, World Bank, *presiding*

This session will introduce and discuss recent developments in governance frameworks for sustainable transportation investments and decision making at different levels around the world. How are transportation agencies across the world institutionalizing and mainstreaming sustainability into their practices? Hear from Denmark, Namibia, the United States, and Latin America.

Denmark's SUSTAIN Project: Creative Group Decision Making for Sustainable Transport Development
Henrik Gudmundsson, Technical University of Denmark

Developing a National Transportation Sustainability Plan for Namibia
Palesa Hekandjo, Roads Authority of Namibia

Sustainability as an Organizing Principle for Transportation Agencies
Gary McVoy, McVoy Associates

The Inter-American Development Bank's Sustainable Infrastructure Framework and Transport Applications in Latin America
Graham Watkins, Inter-American Development Bank

3:15 p.m.–3:30 p.m.
Break

3:30 p.m.–5:00 p.m.

Breakout Sessions

Breakout 3: International Trade and Travel—Striving for Sustainability, *Keck 100*

Tara Ramani, TTI, *presiding*

How can we make the growing flows of international trade and travel more sustainable? Today's supply chains rely on complex, multimodal transportation systems that cross international borders. While some modes are able to switch to low-carbon fuels, options are more limited for international air travel. This session will discuss methods to standardize greenhouse gas emission accounting for global transportation chains, the map sustainability of trade corridors, and will compare and promote sustainable aviation practices.

Global Greenhouse Gas Emission Standardization for Transportation Chains, Generation 2.0: Building on the Achieved, Moving into the Future
Stephen Russell, World Resources Institute

Sustainable Aviation Guidance Alliance: An Interactive Website to Share Sustainability Best Practices
Kristin Lemaster, Changing Climate Consulting

The Policy Effectiveness of Economic Incentives in the Air Transportation Sector: The Comparative Analysis of Offset Programs, Emission Tax, and Emission Trade
Joel Zhengyi Shon, Tainan University of Technology

SUPERGREEN: Mapping Sustainability and Emissions of Trans-European Trade Corridors
George Panagakos, Technical University of Denmark

Breakout 4: Sustainable Transportation and Climate Change, *Keck 101*

Rich Baldauf, U.S. Environmental Protection Agency, *presiding*

Climate Change is inherently an international issue: greenhouse gas emissions anywhere contribute to changes in climate everywhere. This session starts with a presentation on one way in which emissions can affect climate, particularly the impacts of black carbon on artic snowmelt. Then hear about efforts to measure and reduce greenhouse gas emissions in Germany, the United States, and China. Finally, learn about climate impacts on the transportation system and how one transportation agency is responding in order to increase resilience to flooding and extreme heat events induced by climate change.

Potential for Diesel Black Carbon from the United States and Eurasia to Impact Arctic Snowmelt
Jennifer DeWinter, Sonoma Technology

Daily Travel and CO_2 Emissions from Passenger Transport: A Comparison of Germany and the United States
Ralph Buehler and Kyle Lukacs, Virginia Polytechnic Institute

Assessing Household Travel Energy Consumption and Carbon Emissions Based on Urban Form:
A Case of Jinan, China
Yang Jiang, Sustainable Transportation Center, Tsinghua University

Sustainability of DOT Assets to Climate Change Effects

Robert Chamberlin, RSG, Inc.

5:00 p.m.–7:00 p.m., *Keck Atrium*
Reception and Student Poster Session

FRIDAY, MAY 8

7:30 a.m.–11:00 a.m., *Keck 100 Lobby*
Registration

7:30 a.m.–8:30 a.m., *Keck 100 Lobby*
Breakfast

8:30 a.m.–10:00 a.m.
Breakout Sessions

Breakout Session 5: Measuring Sustainability, *Keck 100*
Rachel Healy, WMATA, *presiding*

Transportation agencies strive to provide strong economic, social, and environmental outcomes to the communities they serve. Many in the United States and abroad are now using tools such as INVEST and CEEQUAL to evaluate projects and programs and to monitor improvements in transportation sustainability. This session will present different experiences using INVEST from Texas DOT and Paraguay's Ministry of Public Works and using the CEEQUAL tool in the United Kingdom. The most relevant data needs associated with sustainable transportation performance measurement also will be discussed.

U.S. and International Experience with the INVEST Sustainability Tool
Frank Holzmann, Texas DOT, Daniel González Sosa, and Guillermo González Lopez, Ministry of Communications and Public Works, Paraguay

The United Kingdom's CEEQUAL Sustainability Tool in Action
Roger Venables, CEEQUAL

Sustainable Transportation Performance Evaluation Data Needs
Todd Litman, Victoria Transportation Institute

Breakout Session 6: Envisioning Sustainable Transport of the Future, *Keck 101*
Antoinette Quagliata, Federal Transit Administration, *presiding*

What will the transportation sector look like in the future? How will emerging technologies, autonomous vehicles, and new mobility systems change future transportation scenarios and reshape cities? How can we steer this future in a sustainable direction?

Applying Network-Based Vehicle Concepts for New Global Mobility Paradigms
Yuri Gawdiak, National Aeronautics and Space Administration

The Role of Zero-Emission Vehicle Mandates in the Transition to Sustainable Energy for Motor Vehicles
David Greene, University of Tennessee

Urban Mobility: Systems Upgrade Project
Philippe Crist, Organisation for Economic Co-operation and Development

Connected and Autonomous Vehicles of the Future
Brian Cronin, Federal Highway Administration

10:00 a.m.–10:15 a.m.
Break

10:15 a.m.–Noon
Working Group Discussions

Join your colleagues in animated discussion about key sustainability topics. Each discussion group will develop:

- **Key Findings from the Conference**: How did the presentations on this topic relate? What did we learn? What are the similarities and differences in the sustainability approaches of different countries? What can different countries learn from one another?
- **Research Needs**: Participants will discuss research needs for their topic area based on information gleaned through the conference and ideas sparked by the previous 2 days.

Group A
Developing Countries: Challenges on the Path to Sustainability, *Keck 100*
Ralph Hall, Virginia Polytechnic Institute, *presiding*

Group B
Practitioner's Guidance on Implementing Sustainability, *Keck 101*
Steven Olmsted, Arizona DOT, and Tim Sexton, Minnesota DOT, *presiding*

Group C
Factors Affecting Demand for Transportation and Impact on Sustainability, *Keck 105*
Giovanni Circella, UC Davis, *presiding*

Group D
Roundtable: Role of Government Policies vs. Private Initiatives in Leading the Future, *Keck 106*
April Marchese, FHWA, and Damon Fordham, Cadmus Group, *presiding*

Noon–1:00 p.m., *Keck 100 Lobby*
Lunch

1:00 p.m.–2:30 p.m., *Keck 100*
Closing Plenary Session: The Way Forward
April Marchese, FHWA, *presiding*

In the closing plenary, speakers will draw linkages between ideas brought forward during the conference, sketch overarching themes, and suggest ways in which researchers and practitioners can move forward sustainable transportation goals. Speakers will also present a summary of the key findings and research needs developed by the four working group sessions during the day. The Conference Organizing Committee for the conference will present an award to the winner of the best student poster.

APPENDIX C

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