EDUCATOR'S GUIDE

Transportation: Traffic, Fuel Consumption and Air Pollution.

Disney Presents the Eyes of Nye

For six seasons, millions of students came to understand, appreciate and enjoy the exploration of science through the series, *Bill Nye the Science Guy*. Bill returns with *The Eyes of Nye*, a more in-depth look at science subjects making news, changing lives, and impacting policy. From the future of alternate fuel sources and genetic engineering to population growth trends and issues of race, Bill and his expert cohorts bring science to life right in your classroom, helping you **Motivate** investigation; **Assess** available information; and **Propose** lines of argumentation.

This Educator's Guide includes:

- An **Introduction** that clearly defines the subject and offers an overview of the issue objectives of the guide; how it relates to science from both a social and personal perspective; as well as pertinent questions and insights regarding the topic.
- A listing of all **National Science Education Standards Addressed**.
- Detailed procedures highlighted in the MAP Framework (**Motivate, Assess, Propose**).
- Illustrative **Video Clips** from *The Eyes Of Nye* DVDs with pinpoint chapter cues.
- **Web Site Resources** to help students further investigate and locate research, charts, data as well as experts featured in the program material.
- Easily downloadable **Support Materials** that include articles, transparencies, charts, and much more.

Introduction:

Introduction: " Transportation" refers to our means of getting from one place to another. *The Eyes of Nye—Transportation: Traffic, Fuel Consumption and Air Pollution* describes our infatuation with the car in the United States, the inherent difficulties that choice imposes, and possible ways we can manage to keep that option by identifying and meeting certain needs.

The issue of transportation is essentially one of science, technology, and design. As such, our future solutions to the problems that surround transportation—and the objectives of this guide—focus on identifying our needs both individually and as a society, learning about the science and technological tools that address those needs, and studying and assessing designs that offer alternatives within the constraints we have imposed.

*Check the **MAP Teaching and Learning Framework** to explore the phases (motivate, assess, and propose) used in this guide.*

National Science Education Standards Addressed

Science As Inquiry

- Abilities necessary to do scientific inquiry
  - Identify questions and concepts that guide scientific investigations
  - Recognize and analyze alternative explanations and models
  - Communicate and defend a scientific argument
- Understanding about scientific inquiry

Physical Science

- Chemical reactions
- Motions and forces
- Interactions of energy and matter

Science and Technology

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives

- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

On the DVD:

Transportation: Traffic, Fuel Consumption and Air Pollution – Chapters

Chapter 1: ***Transportation Preview***
Beginning to 1:37
Ends with title screen.

Chapter 2: ***Cars, Choice, and Challenges***
2:01—7:33
Starts with Bill saying, "Since we could first form the question..."

Chapter 3: ***Fuel Cells and Hydrogen Power***
7:34—10:23
Starts with Bill saying, "I'm dancing and singing…"

Chapter 4: ***Costs, Benefits, and Sustainable Energy***
10:23—15:32
Starts with factoids on efficiency of gas and hydrogen.

Chapter 5: ***Urban Sprawl***
15:33—18:40
Starts with Bill saying, "So I'm up here with Bruce…"

Chapter 6: ***Mapping Traffic: A People Science***
18:40—end of program
Starts with Bill asking, "All these cars. All this traffic…" Ends with the close of the program.

Transportation: Traffic, Fuel Consumption and Air Pollution – Activity Clips

Just Give Me My Car!
2:01—3:06
(referenced in Educator's Guide step 1)
Starts with Bill saying, "This used to be the biggest source of pollution…"
Ends with interviewee saying, "That's freedom in America."

Identifying the Constraints
3:08—5:05
(referenced in Educator's Guide step 6)
Starts right after Mr. Sanders with Bill saying, "It takes a lot of energy to get a car to the top of a hill." Ends right as Bill finishes saying, "So car makers have tried a few things."

Charging Forward: Electric Transportation
5:05—6:26
(referenced in Educator's Guide step 6)
Starts with Bill saying, "This is an electric car." Ends with him saying, "…but they're burning emission pumping, nonrenewable gasoline."

The Hindenburg
10:34—11:01
(referenced in Educator's Guide step 7)
Starts with the radio announcer and runs through the historical background on the Hindenburg disaster.

Hydrogen: Power to Change the World?
13:47—15:20
(referenced in Educator's Guide step 7)
Starts with Bill riding a scooter and saying, "We're just at the beginning of this technology." Ends with Dr. Stroh saying, "…power to change the world."

The Fuel Cell
8:22—9:02
(referenced in Educator's Guide step 8)
Starts with Bill saying, "The fuel cells on board convert hydrogen into electricity continuously through a chemical process." Ends with Bill saying, "…just the right amount of electricity."

It's in the Molecules!
11:03—13:00
(referenced in Educator's Guide step 9)
Starts at the beginning of the cartoon with the red school building. Ends with Bill saying, "See, with hydrogen, our odds are a lot better."

More Complicated Than Rocket Science
19:05—22:15
(referenced in Educator's Guide step 13)
Starts as Chris Barrett first appears on screen, and he says, "This is more complicated than rocket science." Ends with Bill saying, "Well that sounds great."

Procedure: Motivate Phase

1) Pose the question, "Who loves cars?" Ask students *why* they love cars and record suggestions on the blackboard or overhead. Assure them that they are not alone; many of us love our car, for many of these same reasons. Play ***"Just Give Me My Car!"*** Suggest that we like things as they are, and perhaps we should leave well enough alone. Pause and wait for a student to question this.

2) Discuss difficulties posed by gasoline-powered vehicles (e.g., emissions of carbon monoxide, nitrogen oxides, sulfur oxides), and ask how we have been addressing this problem. Some students will claim we have been making cars that get better gas mileage, weigh less, or are just more efficient. Tell them we have made many design changes to vehicles in the past decades that have reduced emissions, but that we still have a long way to go. Ask them to consider problems other than the energy source (gasoline). Some may mention traffic—suggest that it is larger than that. Share data illustrating the wasted time and cost of traffic congestion provided in Transportation Tribulations.

Promote need-to-know through awareness of traditional fuel sources, economic impact of vehicle and transportation system designs, and past trends that persist to this day.

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3) Ask if this problem with traffic—keeping us from getting around *and* draining our economy—is getting better. Note the trends from 1982 to 2003 in Transportation Tribulations, and suggest that perhaps we have problems. Ask students to consider whether the problems are new (no), or if we have had any shortage of ideas for how to better "get around." Remind students of our love for cars, and suggest that our dilemma has much to do with what we want and this is important.

Transportation shaped history. Ask students to explore its effects on major events from ancient times forward. Only the details have changed—sometimes, the more things change, the more they stay the same.

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4) Play the ***"Chapter 1: Transportation Preview"*** (end at title frame) and repeat the question, "If we are going to have cars, couldn't we do a better job of it?" Suggest that though it is difficult to keep our cars and improve our transportation problems, maybe we can if we plan and design the cars and systems better. To do this we must be very clear about what we want. We must explore possible scientific and social solutions, and understand that the former (e.g., chemistry of energy and emissions) without the latter (what people want and do), or vice versa, won't work—we have seen this from past experience. Help students construct several focused questions to investigate. At least two should be scientific and one social, and they should relate to design-intent and outcome (see possibilities below).

Potential scientific questions:

a) What are the requirements for life?

b) What evidence have we found, and what methods have we used, that indicate these requirements could possibly be met elsewhere?

Potential social questions:

c) What possible social solutions exist?

See ***The Eyes of Nye*** Issue Support ***Transportation Tribulations***

Procedure: Assess Phase

5) Explain that to determine shortcomings of our transportation systems (first question) we must decide what *we want* and *need.* Recall the purpose of transportation—to physically move people or products—and that *our wants determine shortcomings.* For instance, we want our cars, so things that prevent us from having them are, for now, shortcomings. Divide students into groups of 3-4. Ask each to compile a list of what we want and share ideas with their classmates. Help them categorize, remove redundancies, and compile items into one set (see ideas, above).

What we want may include designs that…

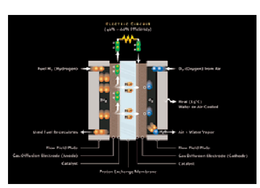
- *are safe and comfortable*
- *are environmentally friendly*
- *save us time getting from place to place*
- *do not waste natural resources, and*
- *reduce costs (for us and products we buy)*

6) Tell students to keep their wants in mind as you play ***"Identifying the Constraints."*** Review the shortcomings discussed and explain that when planners try to design solutions to transportation problems these become design "constraints." Tell students to note the impact that constraints can have on a design—even one that everyone thinks will be successful—as you play ***"Charging Forward: Electric Transportation."*** For instance, our vehicles cannot require a charge every 120 miles, be overly heavy, or emit chemicals that harm the environment. Point out the other side of design—highway systems and the need for less traffic. Ask them to consider the costs for not attending to these aspects—point out safety as one example.

7) Ask students to suggest design features that are important for safety (e.g., air bags, antilock brakes, etc.). Ask who has heard of the Hindenburg—most do not know the story of the German aircraft, largest ever to fly, first with transatlantic commercial service… destroyed in a tragic fire in 1937. As you play ***"The Hindenburg,"*** ask students to note the aircraft's power source and what turned out to be the actual cause of the disaster. Explain that when safety problems arise they can destroy a design concept. We remember disaster—this one could have been responsible for the loss of 61 years of progress, until hydrogen was vindicated in 1998. Explain that the incident further shows the importance of planning and testing repeatedly, and researching design failures as well as successes. Suggest that it also means reinvestigating possible solutions in light of new findings.

*Play **"Hydrogen: Power to Change the World?"** Glowing prospects are portrayed, but encourage students to also ask questions about the extraction of hydrogen, its distribution, and its storage.*

8) Introduce the resurgence of hydrogen power by playing ***"Chapter 3: Fuel Cells and Hydrogen Power"*** (end with Bill tasting water) in which Tony Cochrane and Bill discuss benefits of hydrogen power and increased use of hydrogen-powered buses. Divide students into groups of 3-4 and ask them to



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See ***The Eyes of Nye*** *Issue Support* ***Fuel Cell Structure.***

describe the steps in the conversion of hydrogen to power as you play ***"The Fuel Cell."*** Replay as needed or set up a viewing station. Review steps using the Fuel Cell Structure support (right). Ask students to suggest design benefits (e.g., clean water by-product, less weight than a battery, no need to recharge, etc.). Explain that weighing costs and benefits can help ensure the success of a design, as they will see with other sources of power.

9) Provide each group above with three fuel options (see right) and tell them that "it's in the molecules"—chemistry holds the key for determining many of the costs and benefits associated with each option. Ask them to note the chemical reactions that produce the power to move a vehicle, along with the by-product, for each reaction as you play "*It's in the Molecules!*" Review each reaction, using the information provided in Chemistry, Costs, and Benefits (right).

Teacher Note: *The reactions provided are intended as a sampling to help students understand the importance of "looking beneath the hood" when we consider power options. The issue support "Chemistry, Costs, and Benefits" (in "Fuel Cell Structure" as well) may be used as a transparency or handout. You may also choose to encourage students to explore the manner in which power is produced by other alternative means, as well as the reactions and/or by-products that are emitted.*

For more, go to eyesofnye.org

10) Recall the question posed earlier regarding the possible social solutions that exist, and explain to students these also present certain costs and benefits. Ask students to refer back to the lists of wants they constructed in step 5, and reiterate (and add) items related to planning and design of traffic systems. Ask them to modify and add to their list as you play ***"Chapter 5: Urban Sprawl,"*** (end at close of interview) in which public affairs representative Matt Burdick discusses the expansion of bus service, addition of light rail, and options of freeway enlargement for improving traffic flow in Phoenix. Note particularly the concept of "diminished returns" when the number of lanes exceeds twelve, and the influence of people's behavior on designing freeway systems. Refer to the list of wants and discuss the implication of our behavior on each. Ask students how we design something to account for social complexity—for human beings' behavior. Suggest to students that they will attempt to do just that.

Procedure: Propose Phase

11) Provide students with the following scenario.

A Driving Dilemma - My Downtown Design: The Urban Mobility Report has stated cities of all sizes now have a transportation problem that has become so complex it requires solutions that consider multiple aspects, including increased capacity, efficiency, management of demand, development patterns, and realistic expectations. They also

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Car chemistry? Analyze several fuel options

See ***The Eyes of Nye*** *Issue Support* ***Chemistry, Costs, and Benefits.***

state these solutions should be customized to neighborhoods or portions of a city. How will you design yours?

For more on exploring claims and claimants, go to eyesofnye.org

12) Divide class into groups of 3-4 students and provide each with the Prep Guide: A Driving Dilemma. Assure students the scenario and the suggested solution categories in the guide are very real—they were adapted from the 2005 U.S. Urban Mobility Report, the same source for the problem data they reviewed in Transportation Tribulations (step 2). Review the guide to ensure students understand the general distinctions between the categories, and then ask them to consider their neighborhood and what might be done to address each solution area. You may ask them to approach the task generally, using what they know about their neighborhood (or another in the region) from experience. There is no "right" solution; the report stresses the goal is to improve, and there will always be some traffic problems. You may alternatively require more analysis and detail, and use information or local fact sheets from which students can work, or even ask them to locate the information themselves. Note as well that, regardless of how detailed the approach, reminding students that "time wasted"—at various times of the day and at various locations—is a key to staying "on track." It is a direct indicator, as time wasted reflects unnecessary time in a vehicle and magnifies every type of problem they have previously studied.

13) Ask students to present their "neighborhood design" ideas to their classmates, and discuss each. Tell students that they likely found the task difficult, and inform them there are people and organizations that study these phenomena every day. Play ***"More Complicated Than Rocket Science,"*** in which Chris Barrett, simulation scientist at Los Alamos National Laboratory, discusses the difficult—and impossible to completely solve—task of mapping the *behavior of people* and trying to determine solutions to traffic problems based on that data.

14) Ensure students may be surprised, however, at just how close they came to certain solutions that *have* made a difference in many towns and cities across the country. Distribute or review the Urban Mobility Report findings in Benefits of Action (right), and point out to students they clearly can make a difference.

Students, and the rest of us, can make a difference. See the 2005 Urban Mobility Report's findings on what has worked.

Final Teacher Note: *The difficulty of proposing solutions to transportation problems that plague our society is compounded by several factors. The most pronounced is they rely on people's behaviors. Even in a scientific comparison of vehicle energy sources, people still determine what choices are made and if they are used in a way that proves successful. Additionally, the sheer detail of considerations can be overwhelming. Thus the instructional decision to focus on*

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*It's not easy being charged with finding the right solution, even if it **is** just one town.*

*See **The Eyes of Nye** Issue Support **Prep Guide: A Driving Dilemma.***

*See **The Eyes of Nye** Issue Support **Benefits of Action.***

a local neighborhood, and the option of having students approach their design decisions in a very general manner. In so doing, the process retains its power—the value is in focused thought and discussion, and the important flip-side benefit of students' awareness that there are no single answers, they are quite able to make quality recommendations that stand with those of experts on which our society now relies, and that something can and should *be done.*

For more, go to eyesofnye.org

Further Research

Investigating the Issue: Transportation

The issue of transportation begs proposed action. Students can obtain and assess scientific information related to engine and fuel power production and the chemistry, costs, and benefits related to each and the by-products emitted. In addition to exploring the scientific aspects of the issue in light of accepted scientific norms (*constitutive* criteria such as accuracy, precision, and consistency), students can—must—put the entire issue into the social realm. The issue is, essentially, about people—difficult to quantify, more difficult to predict—but refreshingly easy for students in the early stages of developing awareness of their place in the scientific enterprise.

In addition to the information and claims presented in *The Eyes of Nye - Transportation,* students may access a variety of informative sources including data and statistics, mechanics, and projections. Teachers may direct them to specific information or leave research tasks as open as they feel is necessary for students to adequately explore and assess information related to transportation and relevant designs for addressing the issue.

Exploring the Scientific and Social Aspects of Transportation

The U.S. Department of Transportation (DOT) and the Environmental Protection Agency (EPA) funds and sponsors the principal sources of information related to traffic and alternative fuel sources. These resources are particularly helpful during the "assess" phase of the teacher's guide as students investigate scientific evidence related to the issue of transportation. Access either at:

http://www.dot.gov

http://www.epa.gov

Exploring Transportation Claimants

Tony Cochrane, Matt Burdick, Chris Barnett, and Dr. Ken Stroh provide the principal information in *The Eyes of Nye - Transportation*. Teachers may encourage students to conduct open-ended searches for information related to these individuals and the institutions at which they conduct their work.

Tony Cochrane, engineer	Ballard Power Systems
Matt Burdick, public affairs	Phoenix Transportation Center
Chris Barnett, simulation scientist	Los Alamos National Laboratory
Dr. Ken Stroh, program manager	Institute for Hydrogen and Fuel Cell Research, Los Alamos National Laboratory

Transportation:
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Transportation Tribulations

Measures	1982	1993	2003
… Individual Traveler Congestion			
Annual delay per peak traveler (hours)	16	40	47
Travel Time Index	1.12	1.28	1.37
Number of urban areas with more than 20 hours of delay per peak traveler	5	37	51
… The Nation's Congestion Problem			
Total hours of delay (billion)	.7	2.4	3.7
Total gallons of "wasted" fuel (billion)	.4	1.3	2.3
Cost of congestion (billions of 2003 $)	$12.5	$39.4	$63.1
… Travel Needs Served			
Daily vehicle-miles of travel on major roads (billion)	1.06	1.66	2.14
Annual person-miles of public transportation travel (billion)	22.9	35.1	43.4

Pre-2000 data do not include effect of operational strategies and public transportation.

Travel Time Index – The ratio of travel time in the peak period to travel time at free-flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.

Delay per Peak Traveler – The extra time spent traveling at congested speeds rather than free-flow speeds divided by the number of persons making a trip during the peak period.

Wasted Fuel – Extra fuel consumed during congested travel.

"Major Findings for 2005 – The Big Numbers

The problem can be stated simply – urban areas are not adding enough capacity, improving operations or managing demand well enough to keep congestion from growing larger. Over the most recent 3 years, the contribution of operations improvements has grown from 260 to 340 million hours of congestion relief, but delay has increased by 300 million hours over the same period. Congestion occurs during longer portions of the day and delays more travelers and goods than ever before. And if the current fuel prices are used, the congestion "invoice" climbs another $1.7 billion, which would bring the total cost to about $65 billion."

- The 2005 Urban Mobility Report, Texas Transportation Institute, p.1 -

Source: *The 2005 Urban Mobility Report* (page 1). Texas Transportation Institute. Schrank and Lomax. Sponsored by the American Road & Transportation Builders Association - Transportation Development Foundation, American Public Transportation Association, and the Texas Transportation Institute.

Fuel Cell Structure

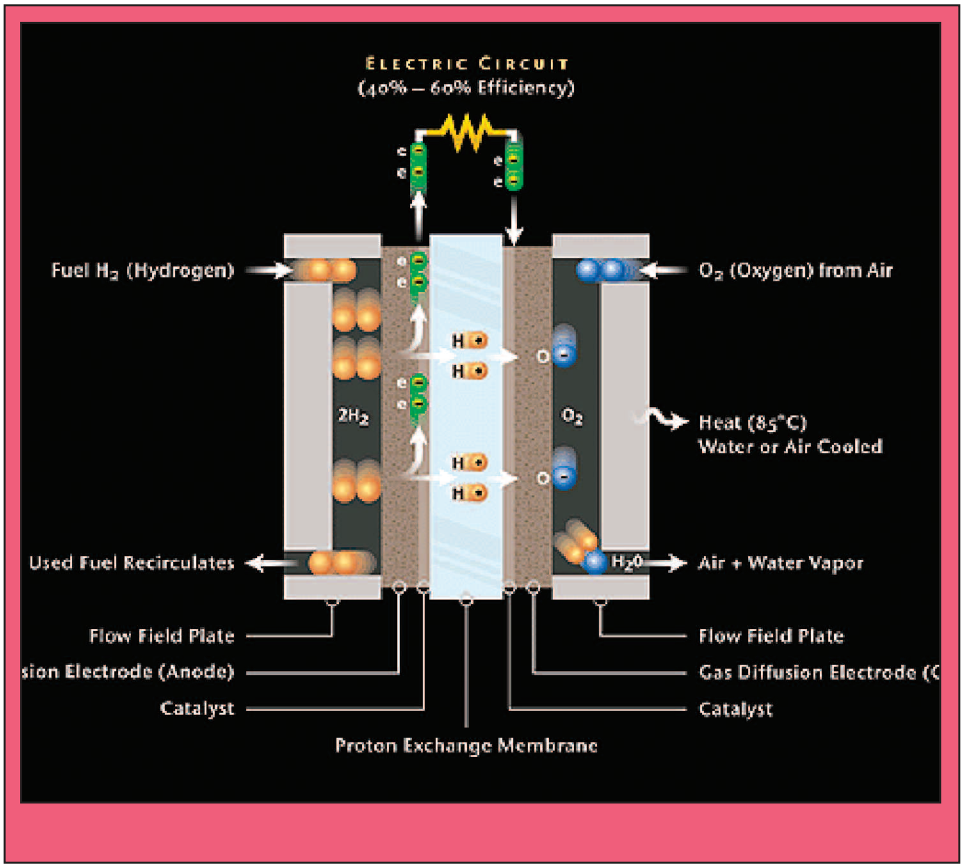

image courtesy of Ballard® Power Systems

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Chemistry, Costs, and Benefits.

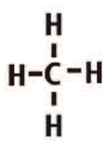
Gas = Octane

When burned:

$C_8H_{18} + O_2 = CO_2 + H_2O$ + Heat

as well as:
CO (Carbon Monoxide)
SO_2 (Sulfur Oxides)
NO_2 (Nitrogen Oxides)

Natural Gas = Methane



When burned:

$CH_4 + O_2 = CO_2 + H_2O$ + Heat

Fuel Cell = Hydrogen

When burned:

$H_2 + O_2 = H_2O$ + Heat

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Prep Guide: A Driving Dilemma

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Types of solutions...	*In my neighborhood...*
Increasing capacity Refers to road construction and public transportation improvement projects. Includes links between major activity centers for people and other transportation portals, toll lanes and highways, and freeway-to-freeway interchanges.	
Improving efficiency Refers to better operation and thus more productivity for present roads and public transportation systems. Includes road congestion warning systems, ongoing education of travelers, and operational treatments such as freeway entrance ramp metering, freeway incident management, traffic signal coordination and arterial street access management.	
Managing demand Refers to changing the way travelers use the roads. Includes traveling in off-peak hours, changing to public transportation services, providing price incentives, etc.	
Modifying development patterns Refers to adjustments in the manner in which residential and commercial developments occur. To gain economic development without increase in mobility is the goal.	
Maintaining realistic expectations Refers to understanding large and heavily populated areas and high-activity centers will be congested, but it does not have to be this way all day, and that small modifications can be made on certain days or times that help in the short run.	

Source: Adapted from solution categories recommended in *The 2005 Urban Mobility Report* (page 5). Texas Transportation Institute. Schrank and Lomax.

Benefits of Action

In 85 large to small urban areas studied between 1982 and 2003, the following actions made a difference to slow the growth and reduce congestion:

Roadway Capacity Increases

When changes in supply more closely match changes in demand, there is less increase in delay. The change in miles traveled was compared to the change in lane-miles for each area. Based on calculation of the change in congestion level:

- 53 highly congested areas showed a significant mismatch—traffic growth increased 30 % faster than the growth in road capacity.
- 28 moderately congested areas showed a closer match—traffic growth between 10 % and 30 percent more than growth of road capacity.
- 4 less congested areas showed a narrow gap—road growth within 10 % of traffic growth.

It is unique that… growth in facilities should be at a slightly greater rate than travel growth in order to maintain constant travel times, and only four areas studied were able to do that.

Public Transportation Service

Regular public transportation service on buses and trains relieves a significant amount of peak period traffic in the most congested areas. If public transportation service were discontinued, the 85 urban areas would have experienced 1.1 billion additional hours of delay in 2003. This would have meant a 27 % increase in delay and an additional cost of $18 billion in wasted time.

It is unique that… the number of people who use the service is small, but concentrated in areas that are the most congested *and* most difficult areas in which to conduct roadwork.

High-Occupancy Vehicle Lanes

High-occupancy vehicle lanes (or HOV lanes, also known as diamond lanes, carpool lanes, and transitways) provide a high-speed alternative to buses. The time saved is most notable during the peak travel periods. Data for 19 congested corridors in eight regions showed a decline of 0.20 for the Travel Time Index measure (comparison of the mainlane freeway congestion levels and the combined freeway and mainlane value). This amounts to 10 to 15 years of congestion growth in the average area. These HOV lanes, provided significant passenger movement at much higher speeds and with more reliable travel times than the congested mainlanes.

It is unique that… at peak travel times, HOV lanes carry one-third of the passenger load as well as improve reliability because they are less affected by collisions or vehicle breakdowns.

Operational Treatments

Four techniques allow existing roadways to provide more regular traffic flow, and reduce collision rates and the effect of vehicle breakdowns. Freeway entrance ramp metering, freeway incident management, traffic signal coordination and arterial street access management reduced time wasted by approximately 336 million hours, saving $5.6 billion.

> ***It is unique that…*** 9 % of the delay was addressed by these treatments, and that if used on all major roads the benefit would expand to 15 % of delay, saving 613 million hours and over $10.2 billion—significant, given that techniques can be enacted much quicker than (not to suggest *in lieu of*) roadway work or public transportation expansion.

Source: *The 2005 Urban Mobility Report* (pages 6-10). Texas Transportation Institute. Schrank and Lomax.