Sustainable Transportation In the 21st Century

Student Workbook
2015–2016

MINETA TRANSPORTATION INSTITUTE
Created by Congress in 1991
Sustainable Transportation in the 21st Century

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Special thanks to Professor Andrea Whittaker and Bill Hanna, College of Education, San José State University for their comments and suggestions.

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Mineta Transportation Institute
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October 2015

Dear Students,

Welcome to the Mineta Transportation Institute’s (MTI) Garrett Morgan Sustainable Transportation Project. It’s all about how we get around. How do you get to school? Do you take the bus or ride your bike? Are you driven to school or do you walk? Whatever you answered, your life is affected every day by the transportation issues that you will learn about in this workbook. What you learn will help you now and in the future to make important choices about sustainable transportation – something explained in this workbook.

After studying what it means to have sustainable transportation, you will develop a project that demonstrates that concept. Your teacher will select a project to represent your class during a national videoconference with other students from around the country. Each participating class will make a presentation at the videoconference, with one winner chosen. A student, parent, and teacher from the winning team will have their travel expenses paid to represent their class at MTI’s annual banquet in June 2015 in San Jose, Calif.

The winning classroom also will receive $500, plus an additional $500 generously contributed by two of MTI’s Trustees, Nuria Fernandez and Will Kempton. Second place will win $300, and third place will win $200. The top three teams also will receive plaques. All students who participate on the presentation teams will receive certificates.

The purpose of this workbook is twofold. First, it will help you learn about sustainable transportation issues. And second, it will help you create a project that addresses these issues. When you have completed the lessons, not only will you know a lot more about one of the most important issues we face in the 21st century, you also will have many ideas for your project.

This workbook is yours. Use it to write your ideas on topics that interest you or that you have questions about. Your notes will help as you proceed with your project. If you participate in the competition, you will interact with the Secretary of Transportation, along with other transportation leaders. You also will comment on the other teams’ projects, and ask questions of the competitors and the transportation leaders.

Complete the workbook and your project using your best critical and creative skills. Someday you will be making important decisions about sustainable transportation. This education will help you make them wisely.

Good luck…

Karen E. Philbrick, PhD
Executive Director
Mineta Transportation Institute

Donna R. Maurillo
Director, Communications and ITT
Mineta Transportation Institute
# Student Workbook Contents

1. **Learning about Transportation**  
   What do you know about transportation?  
   - 4  
   - 5

2. **Transportation History: News and Dates**  
   Your Transportation History Timeline  
   - 6  
   - 9

3. **Current Issues**  
   - Acid Rain  
   - Problems with Fossil Fuels  
   - 10  
   - 11  
   - 12

4. **Transportation Energy Sources**  
   - Energy Source Questions  
   - Evaluating Fuel Sources  
   - Evaluating Transportation Modes  
   - 13  
   - 18  
   - 19  
   - 20

5. **Sustainable Transportation**  
   - Characteristics of Sustainable Transportation  
   - Assessing Sustainable Transportation Options  
   - 21  
   - 22  
   - 23

6. **Transportation Jobs and Professions**  
   - Career Matrix  
   - Career Choice Paper  
   - 24  
   - 24  
   - 25

7. **The Competition**  
   - Types of Projects  
   - Project Format, Judging Criteria, and Hints  
   - 26  
   - 27  
   - 28

8. **Video Conference**  
   - 29
Learning about Transportation

What do you know about transportation? Have you thought about all the reasons people use transportation? Have you thought about the modes of transportation, like a car or a bike? What fuel sources are used for transportation? If you’re like most people, you probably don’t think much about these issues, but answering these questions is the first step toward finding solutions to our transportation problems.
What Do You Know About Transportation?

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<th>Uses</th>
<th>Modes</th>
<th>Energy Sources</th>
<th>Effects</th>
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Transportation History: News and Dates

Transportation history can give us an idea of how things have developed. As you read the following events, think about why they are important. There are no correct or incorrect answers. All the events illustrate different facets of transportation development. You may find that you are most interested in the technology associated with transportation history. Someone else may look at world events and fuel price increases. Others may look at environmental or social costs caused by our reliance on fossil fuels. All these issues are important.

When you read something you think is important, write a few words in the space provided to help you remember why it is important. After you have finished reading all the events, choose five events that you think are most important and create a timeline on the page provided. When you have completed your timeline, write a sentence or two that explains why you think each is important.
Transportation History: News and Dates

June 27, 1652 – The first traffic law is passed in New Amsterdam (New York City). It said, "... to prevent accidents (we) do hereby ordain that no wagons, carts or sleighs shall be run, rode or driven at a gallop within this city of New Amsterdam, ... on the penalty of two pounds Flemish for the first (violation)."

August 9, 1803 – Robert Fulton creates a steamboat that operates up the River Seine in Paris, moving 3-4 miles per hour upstream.

May 3, 1869 – Passenger traffic begins on the first pneumatic subway invented by Alfred Ely Beach. The Beach Pneumatic Underground Railway of New York City includes a 312 foot-long circular tube, 9 feet in diameter. The cars carry 22 passengers and are propelled by a blast of air from a rotary blower.

January 2, 1900 – The first electric bus appears on 5th Avenue in New York City. It seats eight people inside and four outside. The fare is five cents.

October 27, 1904 – The New York City Subway is the first rapid transit underground and underwater railway in the world. It runs from City Hall to West 145th St. About 111,881 people pay 5¢ each to ride for 26 minutes on the express train and 46 minutes on the local train.

April 7, 1913 – The first electrically propelled ship of the U.S. Navy, the USS Jupiter, is commissioned.

November 20, 1923 – Garrett Morgan is granted a patent for inventing the first practical traffic signal.

March 29, 1927 – The first automobile to exceed 200 miles per hour is the "Mystery Sunbeam" driven by Major Henry O'Neil de Hane Segrave at Daytona Beach FL. He hits 203.79 mph.

September 3, 1931 – An experimental electric passenger train, designed by Thomas Alva Edison, is used on the Lackawanna Railroad between Hoboken and Montclair NJ.

July 16, 1935 – The first parking meter, called The Black Mariah, is installed in Oklahoma City OK.

February 20, 1941 – The first jeep is introduced for military use.
Transportation History: News and Dates

Notes

June 29, 1956 – President Dwight Eisenhower signs a bill that creates the first interstate highway in the US. The system is not completed until 1990.


April 12, 1961 – The first human spaceflight is Vostok 1, on which cosmonaut Yuri Gagarin of the USSR makes one orbit around Earth.

October 1, 1964 – Japan’s Shinkansen, the first “bullet train,” opens.

January 28, 1969 – An oil well blows out on a Union Oil Company drilling platform five miles off the coast of Santa Barbara CA. The beaches are covered with oil. In April 2010, the same thing happens in the Gulf of Mexico, where BP was drilling.


June 28, 1979 – OPEC raises prices on crude oil again. The price of a barrel increases 50% over a year earlier.

July 15, 1979 – President Jimmy Carter announces a massive six-point effort to reduce American dependence on foreign oil, including alternative energy development.

March 24, 1989 – The Exxon Valdez oil tanker runs aground in Prince William Sound off Alaska, spilling 232,000 barrels of oil. Only 25% of the migratory salmon population returns the following season, and thousands of otters and birds are poisoned. Many die.

July 19, 2006 – The Tesla Roadster is introduced at the Santa Monica CA airport at a 350-person invitation-only event. It costs more than $100,000.

April 16, 2009 – President Obama unveils his administration's blueprint for a national network of high-speed passenger trains.

December 26, 2009 – China introduces the world’s fastest train, with average speeds of 217 miles per hour.

Your Transportation History Timeline

In the space below, select five transportation events and create your own timeline based on the readings in the workbook and/or other sources. After you have created your timeline, write a sentence or two on each event you selected.

<table>
<thead>
<tr>
<th>Date/Event</th>
<th>Why is it Important?</th>
<th>If negative impact, possible solutions?</th>
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Current Issues

By now, you may notice many social, environmental and economic issues related to transportation. Examining the issues thoroughly is an important part of finding solutions to those problems. In this section you will continue to investigate the problems based on our dependence on fossil fuels.

Fossil fuels were formed from the remains of animals and tiny plants that lived in the oceans many millions of years ago. The main forms of fossil fuels are oil, coal, and gas. According to some experts, at the rate we are burning fossil fuels we will run out of oil and gas in 35-70 years and coal in less than 300 years.

This is only a tiny portion of the vehicles using fossil fuel for energy. Multiply this number of cars around the world, and you can see why we will deplete our sources after a while.
**Acid rain** forms when a chemical reaction occurs between the oxides of nitrogen and sulfur dioxide. These two chemicals react with the moisture in the air and produce the nitric and sulfuric acids present in acid rain. The sulfur and nitrogen compounds that contribute to acid rain primarily come from burning fossil fuels – such as coal and oil – in power plants and transportation. These are called fossil fuels because they were formed from the decayed plants and animals that lived millions of years ago. Fossil fuels are not “renewable – that is, they cannot be replenished – because it takes far too long for living things to become coal or oil.

This acid rain harms forests by depleting the nutrients in the soil and contributing to damage of buildings and statues. Acid rain can pollute bodies of water and harm the wildlife that lives there. Researchers are still studying the possible effects on human health, but many experts say that acid rain contributes to diseases such as emphysema and asthma.

See for Yourself
You can perform a simple experiment with chalk (limestone) and vinegar (an acid) to see the effects of acid rain on buildings and statues. Scratch a design on a piece of chalk, place it in a glass of vinegar, and watch what happens.

The damage to statues on this page shows the effects of acid rain. The gargoyle on the right has been restored after acid rain damage. The tree on the left shows acid rain’s effects. Its branches are thin and long. The tree on the right has a normal crown. The statue of the woman is destroyed.
Problems with Fossil Fuel

Based on your class discussions and previous reading, identify and explain five problems associated with using fossil fuels for transportation.

1.

2.

3.

4.

5.
Transportation Energy Sources

You already have thought about and discussed one energy source, fossil fuels. Other energy sources are important to consider for transportation that meets today’s needs without compromising future needs.

Energy sources can be divided into two main categories – renewable and non-renewable. Renewable sources can be used over again or created in a short time. Wind, sun, and food are renewable energy sources. Fossil fuels like oil, gas, and coal are nonrenewable. They took millions of years to form, so it will take millions more years for Earth to replace the fossil fuels we have used.

Although most of Earth’s energy is renewable, we use non-renewable energy sources for many of our needs. On the following pages are names and descriptions of some fuels and energy sources that can be used for transportation.

Oil is a non-renewable fossil fuel. And when oil is burned, it produces emissions that create acid rain. These pollutants are produced both during the refining process (making oil into gasoline) and when gasoline is burned in engines. Another drawback is that when oil is burned, it releases carbon dioxide. This is a “greenhouse gas” because, like a greenhouse, it traps the sun’s heat close to Earth’s atmosphere and causes global warming. Below is a picture of an oil refinery. The smoke you see contains carbon dioxide, sulfur, and nitrogen.

Uranium is a non-renewable fossil fuel. We split uranium’s atoms to create heat that is converted into electricity. Nuclear power accounts for about 17% of the electricity produced in the world. People have learned that uranium’s constant radiation is very dangerous to living things. Do you remember the earthquake in Japan that damaged a nuclear power plant? What were some concerns about the leaked radiation?
**Natural Gas** is considered by many experts to be the cleanest of all fossil fuels. Because it has no harmful chemicals like sulfur or nitrogen, it does not cause acid rain. However, it does produce methane, which is a worse greenhouse gas than carbon dioxide. To the right is a truck that runs on compressed natural gas (CNG). The tank holds the compressed gas before it is burned in the specially adapted engine. Where else do we use natural gas?

**Coal** is used to make almost half the electricity in the world. Like oil, one of coal’s drawbacks is that when it is burned, it releases the chemicals that cause acid rain. Coal is found close to the Earth’s surface and deep within the Earth’s crust. Coal that is deep must be mined with tunnels. If it is close to the Earth’s surface, it is obtained through a process called strip-mining. In some places coal is mined from big holes or pits in a process called “open-pit mining.”

Open-pit and strip-mines are better for coal miners because they don’t have to work in deep tunnels, but these mines destroy the habitats of plants and animals. Although the land can be returned to its natural state, it is difficult and expensive. To the left you can see coal being prepared for use in a power plant and an oil refinery.

A growing number of **electric vehicles** are now on the road. Government emission regulations and car owners are demanding more environmentally friendly cars. Electric cars “charge up” at special stations and store the electricity in batteries. The car to the right runs on electricity. Can you name some electric vehicles?
Electricity is generally produced in power plants. Power plants often use turbines to power generators that produce electricity. The generators in these plants have electromagnets that spin inside huge copper coils that produce electric current. The energy used to turn the turbines can be created from nonrenewable sources like gas, oil, coal, and uranium or from renewable energy sources like solar, wind, geothermal, and hydropower. Hoover Dam uses the force of channeled water to turn the turbines that produce electricity. Have you ever been to Hoover Dam? It was a huge engineering feat when it was built. This is an important dam that continues to supply electricity for the Los Angeles area.

At Hoover Dam water flows from the forebay or reservoir through channels past the turbines in a draft tube. The water makes the turbines spin.

If you hold your hand under a faucet that is turned on high, you can feel the water’s force. This same energy moves the turbines at Hoover Dam.

Producing electricity in this way doesn’t produce greenhouse gases or acid rain, but building a dam does change the environment. Animals are affected because the river flow is changed and areas are flooded to form the dam’s reservoir.

Inside Hoover Dam

Hoover Dam is on the left. You can see how strong the water force is. To the right are the huge generators powered by turbines at Hoover Dam. When the turbine shafts spin, the magnets inside the generators rotate and produce electric energy. Large electric cables then carry it for distribution.
Geothermal Energy, shown as a geyser above, is produced by using very hot water created by the movement of the earth’s plates. Many volcanoes and geysers are the result of this movement. Engineers can now pump this very hot water and use the steam or water vapor to turn turbines in power plants that produce electricity.

Geothermal power plants are very expensive to build, but once they are built, they are not expensive because the hot water is free. Today more than 250 geothermal power plants have been built. Like many renewable

Wind Energy: Windmills, shown at left, have been used for hundreds of years to pump water and grind grain. Today windmill shafts are hooked to turbines that produce electricity. Wind energy works best in places that have strong winds, like coastal areas, mountain passes, and prairies. Wind plants are expensive to build, but like other renewable energy sources, once the plant is built, the wind is free. Wind energy is non-polluting, although the windmills can harm birds and wildlife. Where have you seen these windmills?

Fuel Cells, shown above, produce energy from the oxygen and hydrogen in the air. Unlike turbines, which create mechanical energy, fuel cells create chemical energy. While the fuel cell powers the engine, the car still needs a liquid or gaseous fuel to keep the chemical reaction going. Unlike a gas engine that gets from 15-40 miles per gallon, a car equipped with fuel cells could get 60-100 miles per gallon.

Fuel cells are not new. In the 1960s, the Gemini Space Project used fuel cells to supply electricity to the space capsules. Today fuel cell buses are used in Ontario, Canada and Chicago, Illinois. Fuel cells are also used to produce electricity in power plants. The largest fuel cell power plant is in Santa Clara, California.
There Are More Sources…

These are just some of the many renewable energy sources in development. Perhaps you have heard of others. Can you name any of them? For example, some researchers are trying to extract oil from algae. Others believe they can create fuels from corn and other plant sources. What other types of renewable energy have you heard of? And what others do you think could be possible?

Solar Energy is energy from the sun. You may have a solar calculator or lights that use a photovoltaic cell to convert sunlight into electricity. When the sunlight hits the cell, the protons and electrons move and create electricity. Photovoltaic cells are expensive, but the cost is coming down quickly. Because we will always have sunlight, solar power is an exciting renewable energy source. To the left is an electric car preparing to charge its battery using solar power. A solar refractor is shown below.

Lightning Energy Shown at left, one bolt of lightning could supply the energy needs for an entire city for a whole year. Scientists are trying to predict exactly when lightning will strike so we can begin to harness this awesome and tremendous energy source. This time-lapse photo shows lighting strikes in Boston. Have you been in a lightning storm?
Energy Source Questions

1. Can you name five renewable energy sources?

______________________________________________________________________

______________________________________________________________________

2. Can you name three ways we produce electricity from renewable energy sources?

______________________________________________________________________

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3. Can you name three non-renewable energy sources?

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4. Why do you think we use non-renewable resources?

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5. What types of fuels are made from biomass?

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6. What produces acid rain?

______________________________________________________________________

______________________________________________________________________
Evaluating Fuel Sources

Complete the table below. Down the side of the table, name the types of fuels and energy sources that you know about. Evaluate each fuel source against the criteria listed at the top. You can use a three-point scale with 1 being the worst and 3 the best.

**Fuel Source Evaluation Table**

<table>
<thead>
<tr>
<th>Source</th>
<th>Pollution</th>
<th>Renewability</th>
<th>Current Availability</th>
<th>Health and Safety</th>
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Evaluating Transportation Modes

This table is similar to the first. This time write down all the transportation modes you know. Evaluate each transportation mode with the same three-point scale you used on the previous worksheet.

Transportation Evaluation Table

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<th>Mode</th>
<th>Speed</th>
<th>Convenience</th>
<th>Cost</th>
<th>Access</th>
<th>Pollution</th>
<th>Fuel Efficiency</th>
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Sustainable Transportation

By now you already know a lot about transportation. If somebody asked you what sustainable transportation was, you’d probably have quite a bit to say. You could tell them about the different fuels available and explain the various social, economic, and environmental costs associated with them. You could also talk about why transportation must be convenient and fast so people will use it. You could explain benefits and drawbacks of mass transportation. How much the transportation costs and whether it can be made universally available are other issues that you might discuss with someone who asked you about transportation.

But if someone asked you for a definition, you might have a bit of trouble. People who work in sustainable transportation have developed the following definition:

“Meeting the needs of the present without compromising the ability of future generations to meet their own needs.”

When you think about it, this definition includes many possibilities. What might those be? Sustainable transportation can include using mass transit, like buses, trains, light rails, and carpools. It could also be about using fuel efficiently. It can be about how employers address transportation issues by allowing employees to telecommute, have staggered shifts, or work longer hours so they don’t have to make so many trips to work or drive during rush hours. All these concepts and many others are part of sustainable transportation.
## Characteristics of Sustainable Transportation

Use the worksheet below to identify and explain six desirable characteristics of sustainable transportation.

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<th>Characteristic</th>
<th>Why Is It Desirable?</th>
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## Assessing Sustainable Transportation Options

List four sustainable transportation modes and several positive and negative attributes for each.

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<th>Mode</th>
<th>Positive Attributes</th>
<th>Negative Attributes</th>
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Transportation Jobs and Professions

Many people are employed in transportation – from operating transportation modes (e.g., pilots, bus drivers, train engineers) to designing and building the vehicles. Some are transportation planners, deciding how best to keep vehicles moving. Others may work in accounting, helping to budget and manage the money for construction projects. Some may work in road construction or maintenance, or they may communicate with the people who use the roadways and transit systems so everyone knows when a new highway will be built or when traffic must be re-routed. If you can think of a career, it’s very likely that it can be applied to transportation in some way.

Career Matrix

Research four transportation careers from web sites and other sources. For each career, write at least one work task, educational requirement, reward, and challenge.

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<tr>
<th>Career</th>
<th>Work Tasks</th>
<th>Education</th>
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Career Choice Paper

Write a paper in which you choose a transportation career and tell why you would make that choice for yourself based on the work tasks, educational requirements, rewards, and challenges.
The Competition

It is not necessary to create a project based exclusively on material in this workbook. These exercises simply provide insight into transportation, energy sources, environmental effects, career choices, etc. Your project should incorporate any aspect of sustainable transportation, but you can be as creative as you like.

For transcripts of previous competitions, along with their project descriptions, go to www.transweb.sjsu.edu. Click on “Education” and then on “Garrett Morgan Program.” Scroll down to the PDF links. These transcripts will show what other competition teams have done, and they may give you good ideas for your own project.

Each classroom team that completes a project may enter that project into the competition. Up to two teams per school are permitted. If a large number of teams participate, we may ask the teacher to make the first judging and then send the best entry to the competition. A written description of the project entries must be mailed to:

Director of Communications
Mineta Transportation Institute
210 North Fourth Street
Fourth Floor
San Jose, California 95112

Project descriptions must be received at the Mineta Transportation Institute (MTI) by 5pm Friday, January 22, 2016 or postmarked by midnight on that date. Include photographs that show the display and/or prototype, if you wish.

The video conference for the top entries will take place around mid-March 2015, the exact date depending on the schedule for US Secretary of Transportation, who will attend the meeting. We also avoid spring break or state testing dates for each school. We likely will not have a firm date until early February 2016 because the Secretary’s office must plan room for Cabinet meetings and official travel. Winners will be notified within a week following the competition.

MTI will provide transportation and up to two nights’ lodging for the Awards Banquet on Saturday, June 18 (or 25*), 2016 for the first place student team leader, the team teacher, and one parent or guardian. If desired, a teacher and two students may attend instead.

The winning team will receive $500 for its classroom, plus an additional $500 generously contributed by two of MTI’s Trustees, Nuria Fernandez and Will Kempton. Second-place team will receive $300, and third-place team will receive $200. Top three teams also will receive a plaque. All participating students will receive a certificate. The decision of the judges is final.

*The firm date had not been set before this publication went to press.
Types of Projects

By completing a team project, you can apply what you have learned in this unit and use your imagination to develop innovative sustainable transportation solutions. Each team can include up to five students in your class.

Your project should be based on a vehicle and/or a system of transportation or an idea for solving part(s) of the sustainable transportation problem. Below are some suggestions, but you may think of others. For ideas, go to the Garrett Morgan page on the MTI web site and download the transcripts from previous competitions: Go to www.transweb.sjsu.edu. Click on “Education” and then “Garrett Morgan Program.” Scroll down to the PDF links.

Science & Technology

**Project.** Develop your own transportation system or mode. This can be a new car, a better bus, or a transportation plan for an entire city or one just for friends. You can describe your idea in writing and with pictures, drawings, graphs, and/or models. In the past, many teams have created vehicles that use solar or wind power. We encourage you to think beyond these types of fuel and come up with something new. Imagination counts!

Social Science

**Legislation.** If you were mayor, governor, or president, what laws do you think would help make better transportation systems? Write some local, state, or federal legislation that will promote sustainable transportation. After you write the legislation, explain why it will be beneficial. What problems still remain to be solved? Use slides, graphs, or other visual aids.

**Research Study.** Document current sustainable transportation practices in your community. The project can include any transportation mode, method, or anything that encourages sustainable transportation where you live. Are those practices successful? How can they be improved? What problems are still not being addressed? What particular groups of people are not being served? How would you serve them better?
Project Format

Legislation Requirements: Papers proposing new legislation must be at least five double-spaced pages. You may include pictures, charts, graphs and references to make the paper no more than ten pages. Be prepared to present your paper with PowerPoint slides or models.

Display Requirements: If you wish to make a project display, the description and graphics must be mounted on a self-standing poster board. You can build a model to enhance your illustrations. The model should be large enough to be clearly visible on a video conference screen.

Video Requirements: You may create a video up to two minutes to support your project. This could be an advertisement, a demonstration, examples of current technology, etc.

PowerPoint Requirements: PowerPoints are popular for these projects. Be sure your text is clear. Do not crowd too many words on a slide. Use no more than ten slides.

Time Limit: Your project presentation must be 8-10 minutes.

Judging Criteria

The competition will have 3-4 impartial judges who will have no personal interest in the outcome. They will award a maximum of 130 points (plus extra credit on the Q&A) based on several criteria, including:

- Is the presentation, PowerPoint, or paper clearly done?
- Is the project sustainable and will it be positive for the environment?
- Do the students speak clearly and knowledgeably?
- Do the students ask and answer questions intelligently?
- Does the team work well together and are they prepared?

Hints

- Judges like presentations that are enthusiastic and clear.
- Practice several times! Judges can tell when you haven’t practiced.
- Have other students challenge your idea so you can learn how to defend it.
- Speak clearly and slowly. The judges want to hear you.
- Have fun. Everyone is really interested in your project!
Videoconference

After your projects are completed, your teacher will select a team to present its project during the videoconference. **Your team will receive extra points for asking and answering questions of the other competing teams.** You also will be able to ask questions of the Secretary of Transportation and other transportation leaders. Here is a form that your teacher can photocopy. Take several copies to the broadcast. As each team makes its presentation, write down the questions you want to ask.

### Videoconference Questions

**Question for which team?**

____________________________________

____________________________________

**What is your question?**

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