APPENDIX A

Highway Investment Analysis Methodology

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Highway Investment Analysis Methodology

Investments in highway resurfacing and reconstruction and in highway and bridge capacity expansion are modeled by the Highway Economic Requirements System (HERS), which has been used since the 1995 C&P Report. This appendix describes the basic HERS methodology and approach in slightly more detail than is presented in Part II including the model features that have changed significantly since the 2010 C&P Report: the valuation of travel time and the equations for emissions costs

Highway Economic Requirements System

The HERS model begins the investment analysis process by evaluating the current state of the highway system using information on pavements, geometry, traffic volumes, vehicle mix, and other characteristics from the Highway Performance Monitoring System (HPMS) sample dataset. Using section-specific traffic growth projections, HERS forecasts future conditions and performance across several funding periods. As used in this report, the future analysis covers four consecutive 5-year periods. At the end of each period, the model checks for deficiencies in eight highway section characteristics: pavement condition, surface type, volume/service flow (V/SF) ratio (a measure of congestion), lane width, right shoulder width, shoulder type, horizontal alignment (curves), and vertical alignment (grades).

After HERS determines that a section's pavement or capacity is deficient, it identifies potential improvements to correct some or all of the section's deficient characteristics. The HERS model evaluates seven kinds of improvements: resurfacing, resurfacing with shoulder improvements, resurfacing with widened lanes (i.e., minor widening), resurfacing with added lanes (i.e., major widening), reconstruction, reconstruction with widened lanes, and reconstruction with added lanes. For reconstruction projects, the model allows for upgrades of low-grade surface types when warranted by sufficient traffic volumes. For improvements that add travel lanes, HERS further distinguishes between those that can be made at "normal cost" and those on sections with limited widening feasibility that could only be made at "high cost." HERS may also evaluate alignment improvements to improve curves, grades, or both.

Q&A

Where can I find more detailed technical information concerning the HERS model?

The most recent comprehensive documentation of the HERS model is a Technical Report from December 2000 that is based on the version of HERS used in the development of the 1999 C&P Report. An updated Technical Report based on the version of HERS used for the 2012 C&P Report will be released in 2013.

More current documentation is available for a modified version of HERS that the Federal Highway Administration developed for use by States. This model, HERS-ST, builds on the primary HERS analytical engine with a number of customized features to facilitate analysis on a section-by-section basis. The 2005 Technical Report on HERS-ST describes a version largely based on the version of HERS that was used to develop the 2004 C&P Report. See http://www.fhwa.dot.gov/asset/hersst/pubs/tech/tech00.cfm for more information.

When evaluating which potential improvement, if any, should be implemented on a particular highway section, HERS employs incremental benefit-cost analysis. Such an analysis compares the benefits and costs of a candidate improvement relative to a less-aggressive alternative—for example, reconstructing and adding lanes to a section may be compared with reconstruction alone. The HERS model defines benefits as reductions in direct highway user costs, agency costs, and societal costs. Highway user benefits include reductions in travel time costs, crash costs, and vehicle operation costs (e.g., fuel, oil, and maintenance costs); agency benefits include reduced routine maintenance costs (plus the residual value of projects with longer expected service lives than the alternative); and societal benefits include reduced vehicle emissions.

Increases in any of these costs resulting from a highway improvement (such as higher emissions rates at high speeds or the increased delay associated with a work zone) would be factored into the analysis as a negative benefit ("disbenefit").

Dividing these improvement benefits by the capital costs associated with implementing the improvement results in a benefit-cost ratio (BCR) that is used to rank potential projects on different highway sections. The HERS model implements improvements with the highest BCR first. Thus, as each additional project is implemented, the marginal BCR declines, resulting in a decline in the average BCR for all implemented projects. However, until the point where the marginal BCR falls below 1.0 (i.e., costs exceed benefits), total net benefits continue to increase as additional projects are implemented. Investment beyond this point is not economically justified because it would result in a decline in total net benefits.

Because the HERS model analyzes each highway section independently rather than the entire transportation system, it cannot fully evaluate the network effects of individual highway improvements. Although efforts have been made to indirectly account for some network effects, HERS is fundamentally rooted to its primary data source, the national sample of independent highway sections contained in the HPMS. To fully recognize all network effects, it would be necessary to develop significant new data sources and analytical techniques.

Highway Operational Strategies

One of the key modifications to HERS featured in previous reports was the ability to consider the impact of highway management and operational strategies, including Intelligent Transportation Systems (ITSs), on highway system performance. This feature is continued in this report with only minor modifications. Current and future investments in operations are modeled outside of HERS, but the impacts of these deployments affect the model's internal calculations and, thus, also affect the capital improvements considered and implemented in HERS.

Among the many operational strategies available to highway agencies, HERS considers only certain types based on the availability of suitable data and empirical impact relationships. Grouped by category, these are:

- Arterial Management
  - Signal Control
  - Electronic Roadway Monitoring (considered a supporting deployment necessary to other operations strategies)
  - Variable Message Signs (VMS)
- Freeway Management
  - Ramp Metering (preset and traffic-actuated)
  - Electronic Roadway Monitoring (considered to be a supporting deployment necessary to other operations strategies)
  - VMS
  - Integrated Corridor Management, with and without comprehensive deployment of Vehicle Infrastructure Integration (VII) technologies[1]. Integrated Corridor Management coordinates the operation of the infrastructure elements within a corridor—for example, the timing of traffic signals near freeway interchanges with freeway incident management and ramp metering
  - Active Traffic Management, which includes lane controls, queue warning systems, and Variable Speed Limits (VSL), also known as "speed harmonization"

- Incident Management (freeways only)
  - Incident Detection (free cell phone call number and detection algorithms)
  - Incident Verification (surveillance cameras)
  - Incident Response (on-call service patrols)
- Traveler Information
  - 511 systems
  - Advanced in-vehicle navigation systems with real-time traveler information (enabled by VII deployment)
  - Incident response (on-call service patrols).

Creating the operations improvements input files for use in HERS involved four steps: determining current operations deployment, determining future operations deployments, determining the cost of future operations investments, and determining the impacts of operations deployments. Different levels and types of deployments can be selected for an individual scenario.

Current Operations Deployments

To determine current operations deployments on the HPMS sample sections, data from the ITS Deployment Tracking Survey were used (http://www.itsdeployment.its.dot.gov/). These data were assigned to HPMS sample sections for each urbanized area using existing congestion and traffic levels on those sections as criteria.

Future Operations Deployments

For future ITS and operational deployments, projections were developed based on three alternatives. For the "Continuation of Existing Deployment Trends" alternative, existing deployments in urban areas were correlated with the congestion level and area population in order to predict on the basis of these factors where future deployments will occur. This alternative is reflected in the analyses presented in Chapters 7 and 8.

The other two alternatives are reflected in sensitivity analysis presented in Chapter 10. The "Aggressive Deployment" alternative assumes that deployment accelerates above existing trends and expands to more advanced strategies. Under this alternative, advanced in-vehicle navigation systems that provide real-time traveler information would supersede the current 511 systems. The "Full Immediate Deployment" alternative takes all of the deployments made in the first 20 years of the "Aggressive Deployment" alternative and assigns them to the first year. The "Full Immediate Deployment" alternative is intended to illustrate the maximum potential impact of the strategies and technologies modeled in HERS on highway operational performance. *Exhibit A-1* identifies the strategies employed in each alternative.

Operations Investment Costs

The unit costs for each deployment item were taken from the U.S. Department of Transportation's (DOT's) ITS Benefits Database and Unit Costs Database and supplemented with costs based on the ITS Deployment Analysis System (IDAS) model. Costs were broken down into initial capital costs and annual operating and maintenance costs. Additionally, costs were determined for building the basic infrastructure to support the equipment, as well as for the incremental costs per piece of equipment that is deployed.

Exhibit A-1 Types of Operations Strategies Included in Each Scenario

Operations Strategy	Scenario: Continue Existing Trends	Scenario: Aggressive and Full Immediate Deployment
Arterial Management		
Signal Control	●	●
Emergency Vehicle Signal Preemption	●	●
Variable Message Signs	freeways only	freeways & arterials
Advanced Traveler Information		●
Freeway Management		
Ramp Metering	●	●
Variable Message Signs	●	●
511 Traveler Information	●	
Advanced Traveler Information		●
Integrated Corridor Mgmt.		●
Active Traffic Mgmt.		●
Incident Management (Freeways Only)		
Detection	●	●
Verification	●	●
Response	●	●

Source: Highway Economic Requirements System.

Impacts of Operations Deployments

Exhibit A-2 shows the estimated impacts of the different operations strategies considered in HERS. These effects include:

- Incident Management: Incident duration and the number of crash fatalities are reduced. Incident duration is used as a predictor variable in estimating incident delay in the HERS model.
- Signal Control: The effects of the different levels of signal control are directly considered in the HERS delay equations.
- Ramp Meters, VMS, VSL, Integrated Corridor Management, and Traveler Information: Delay adjustments are applied to the basic delay equations in HERS. VSL is assumed to have a small impact on fatalities as well.

Based on the current and future deployments and the impact relationships, an operations improvements input file was created for each of the two deployment scenarios. The file contains section identifiers, plus current and future values (for each of the four funding periods in the HERS analysis) for the following five fields:

- Incident Duration Factor
- Delay Reduction Factor
- Fatality Reduction Factor
- Signal Type Override
- Ramp Metering.

Exhibit A-2 Impacts of Operations Strategies in HERS

Operations Strategy	Impact Category	Impact
Arterial Management		
Signal Control	Congestion/Delay	Signal Density Factor = n(nx+2)/(n+2), where n = no. of signals per mile x = 1 for fixed time control 2/3 for traffic actuated control 1/3 for closed loop control 0 for real-time adaptive control/SCOOT/SCATS Signal Density Factor is used to compute zero-volume delay due to traffic signals
Electronic Roadway Monitoring	Congestion/Delay	Supporting deployment for corridor signal control (two highest levels) and traveler information
Emergency Vehicle Signal Preemption		
Variable Message Signs	Congestion/Delay	-0.5% incident delay
Freeway Management		
Ramp Metering		
Preset	Congestion/Delay	New delay = ((1 - 0.13)(original delay)) + 0.16 hrs per 1000 VMT
Traffic Actuated	Congestion/Delay	New delay = ((1 - 0.13)(original delay)) + 0.16 hrs per 1000 VMT
	Safety	-3% number of injuries and property damage only accidents
Electronic Roadway Monitoring	Congestion/Delay	Supporting deployment for ramp metering and traveler information
Variable Message Signs	Congestion/Delay	-0.5% incident delay
Integrated Corridor Management	Congestion/Delay	-7.5% total delay without VII, 12.5% total delay with VII
Active Traffic Management	Congestion/Delay Safety	-7.5% total delay -5% fatalities
Incident Management (Freeways Only)		
Detection Algorithm/ Free Cell	Incident Characteristics Safety	-4.5% incident duration -5% fatalities
Surveillance Cameras	Incident Characteristics Safety	-4.5% incident duration -5% fatalities
On-Call Service Patrols		
Typical	Incident Characteristics Safety	-25% incident duration -10% fatalities
Aggressive	Incident Characteristics Safety	-35% incident duration -10% fatalities
All Combined	Incident Characteristics Safety	Multiplicative reduction -10% fatalities
Traveler Information		
511 Only	Congestion/Delay	-1.5% total delay, rural only
Advanced Traveler Information (VII-enabled)	Congestion/Delay	-3% total delay, all highways

Source: Highway Economic Requirements System.

HERS Improvement Costs

For the 2004 C&P Report, significant changes were made to the structure of the HERS improvement cost matrix, the assumed unit costs in that matrix, and the manner in which those values were applied. The improvement cost updates reflected in the 2004 C&P Report were based on highway project data from six States (see Appendix A of that report for more information) that, although adequate in most respects, were relatively thin in certain key areas. The 2004 update disaggregated the improvement cost values in urban areas by functional class and by urbanized area size. Three population groupings were used: small urban (populations of 5,000 to 49,999), small urbanized (populations of 50,000 to 200,000), and large urbanized (populations of more than 200,000). However, the data used to create values for the large urbanized areas did not include a significant number of projects in very large urbanized areas, and concerns were raised about the degree of construction cost comparability within this category.

For the 2006 C&P Report, additional project cost data were collected for large urbanized areas, rural mountainous regions, and high-cost capacity improvements. These data were used to update the HERS improvement cost matrix, which was also modified to include a new category for major urbanized areas with populations of more than 1 million. The HERS improvement cost matrix was adjusted further for the 2008 C&P Report based on some additional analysis of the data previously collected. For this report, no changes were made to the cost matrix except to adjust it for the change in the National Highway Construction Cost Index between 2006 and 2010.

Exhibit A-3 identifies the costs per lane mile assumed by HERS for different types of capital improvements. For rural areas, separate cost values are applied by terrain type and functional class, while costs are broken down for urban areas by population area size and type of highway. These costs are intended to reflect the typical values for these types of projects in 2010, and thus do not reflect the large variation in cost among projects of the same type, even in a given year. Such variation is evident in the project-level data on which these typical values are based, and are attributable to a number of location-specific factors. For example, the costs assumed for highway widening projects will be predicated on each section having a number of bridges typical for its length, but in reality some sections will have more bridges than other sections of equal length, which adds to costs. Among other factors that could make costs unusually high are complicated interchanges, major environmental issues, and/or other extreme engineering issues.

The values shown for adding a lane at "Normal Cost" reflect costs for projects where sufficient right-of-way is available or could be readily obtained to accommodate additional lanes. The values for adding lane equivalents at "High Cost" are intended to reflect situations in which conventional widening is not feasible and alternative approaches are required in order to add capacity to a given corridor. Such alternatives include the construction of parallel facilities, double-decking, tunneling, or the purchase of extremely expensive right-of-way. HERS models these lane equivalents as though they are part of existing highways, but some of this capacity could come in the form of new highways or investment in other modes of transportation.

Allocating HERS Results Among Improvement Types

Highway capital expenditures can be divided among three types of improvements: system rehabilitation, system expansion, and system enhancements (see Chapters 6 and 7 for definitions and discussion). All improvements selected by HERS that do not add lanes to a facility are classified as part of system rehabilitation, and highway projects that add lanes to a facility normally include resurfacing or reconstructing the existing lanes. HERS therefore splits the costs of such projects between system rehabilitation and system expansion.

Exhibit A-3 Typical Costs per Lane Mile Assumed in HERS, by Type of Improvement

(Thousands of 2010 Dollars per Lane Mile)

Category	Reconstruct and Widen Lane	Reconstruct Existing Lane	Resurface and Widen Lane	Resurface Existing Lane	Improve Shoulder	Add Lane, Normal Cost	Add Lane, Equivalent High Cost	New Alignment, Normal	New Alignment, High
Rural									
Interstate									
Flat	$1,409	$920	$797	$327	$61	$1,811	$2,510	$2,510	$2,510
Rolling	$1,579	$944	$918	$348	$100	$1,963	$3,177	$3,177	$3,177
Mountainous	$2,994	$2,067	$1,521	$515	$210	$6,113	$7,156	$7,156	$7,156
Other Principal Arterial									
Flat	$1,100	$737	$665	$262	$41	$1,451	$2,076	$2,076	$2,076
Rolling	$1,242	$757	$756	$292	$68	$1,553	$2,507	$2,507	$2,507
Mountainous	$2,413	$1,705	$1,465	$412	$89	$5,483	$6,314	$6,314	$6,314
Minor Arterial									
Flat	$1,006	$647	$620	$232	$38	$1,318	$1,851	$1,851	$1,851
Rolling	$1,215	$716	$771	$250	$70	$1,511	$2,384	$2,384	$2,384
Mountainous	$2,018	$1,323	$1,465	$343	$159	$4,629	$5,555	$5,555	$5,555
Major Collector									
Flat	$1,060	$685	$640	$237	$49	$1,370	$1,850	$1,850	$1,850
Rolling	$1,160	$696	$720	$252	$66	$1,399	$2,277	$2,277	$2,277
Mountainous	$1,758	$1,089	$1,048	$343	$101	$2,963	$3,870	$3,870	$3,870
Urban									
Freeway/Expressway/Interstate									
Small Urban	$2,297	$1,591	$1,810	$386	$71	$2,882	$9,434	$3,884	$13,259
Small Urbanized	$2,469	$1,605	$1,873	$457	$94	$3,170	$10,346	$5,236	$17,873
Large Urbanized	$3,938	$2,626	$2,900	$613	$354	$5,270	$17,676	$7,679	$26,216
Major Urbanized	$7,877	$5,253	$5,629	$1,015	$707	$10,540	$43,953	$15,359	$58,755
Other Principal Arterial									
Small Urban	$2,002	$1,351	$1,657	$324	$72	$2,450	$8,002	$3,062	$10,451
Small Urbanized	$2,142	$1,368	$1,732	$383	$96	$2,654	$8,702	$3,778	$12,895
Large Urbanized	$3,060	$2,005	$2,534	$481	$309	$3,884	$12,977	$5,186	$17,702
Major Urbanized	$6,120	$4,009	$5,068	$777	$617	$7,768	$30,113	$10,372	$44,897
Minor Arterial/Collector									
Small Urban	$1,475	$1,021	$1,253	$237	$52	$1,809	$5,860	$2,209	$7,542
Small Urbanized	$1,546	$1,032	$1,265	$269	$64	$1,906	$6,194	$2,711	$9,254
Large Urbanized	$2,081	$1,380	$1,729	$331	$173	$2,643	$8,774	$3,528	$12,042
Major Urbanized	$4,162	$2,761	$2,616	$550	$347	$5,285	$30,113	$7,056	$37,264

Source: Highway Economic Requirements System.

Costs of Air Pollutant Emissions

Greenhouse Gas Emissions

Road traffic generates an appreciable share of anthropogenic emissions of greenhouse gases (GHG). In the United States, passenger vehicles alone account for roughly 20 percent of emissions of carbon dioxide, and CO_2 emissions account for about 95 percent of the total global warming potential from all U.S. emissions of GHGs. In line with carbon dioxide emissions being the dominant concern relating to global warming, the HERS model has included a capability for quantifying and costing these emissions starting with the version of the model used for the 2010 C&P Report.

The quantification of CO_2 emissions from motor vehicle traffic is based on the amounts of gasoline and diesel fuel consumed (alternative fuels have yet to be incorporated into the model). Emissions directly from vehicles amount to 8,852 grams of CO_2 per gallon of gasoline consumed, and 10,239 grams per gallon of diesel fuel.[2] These are often referred to as tailpipe emissions, because they result from the fuel combustion process in motor vehicles' engines. In addition to these direct emissions, the fuel production and distribution processes produce CO_2 emissions as well, which are often referred to as upstream emissions. HERS allows users of the model the option of adding these upstream emissions, about which there is greater quantitative uncertainty, to its estimates of direct or tailpipe CO_2 emissions. HERS' estimates of upstream emissions are 2,072 grams of CO_2 per gallon of gasoline consumed, and 2,105 grams CO_2 per gallon of diesel.

HERS uses these estimates of CO_2 emissions per gallon of fuel consumed to convert vehicles' fuel consumption rates to CO_2 emissions per vehicle mile. The resulting estimates of CO_2 emissions per vehicle mile are then converted to dollar costs using estimates of climate-related economic damages caused by CO_2 emissions. A recent study by a Federal interagency working group (Interagency Working Group on Social Cost of Carbon 2010) estimated the costs to society from future climate-related economic damages caused by incremental CO_2 emissions. The group's estimates of this social cost of carbon were intended to include, at a minimum, the monetized impacts of emissions-induced climate change on net agricultural productivity, on human health, on property damages from increased flood risk, and on the value of ecosystem services. Low, medium, and high estimates of the social cost per metric ton of carbon were formed for each year from 2010 through 2050 using alternative discount rates. All estimates were originally reported in 2007 dollars.

The analyses presented in this report have used the medium estimates, and updated them to 2010 dollars using the gross domestic product price deflator (as was done in a recent analysis of corporate average fuel economy standards conducted by the National Highway Traffic Safety Administration). The adjusted values of CO_2 damage costs increase annually from $22.22 per metric ton in 2010 and reach $34.06 by 2030, the final year for which this report projects highway conditions and performance. For use as HERS inputs, the values were averaged to produce estimates of CO_2 damage costs for each 5-year HERS funding period. At the same time, however, vehicles' fuel consumption rates—and, thus, the rates at which they emit CO_2—are projected to decline in the future as the more fuel-efficient models required by Federal regulations replace older vehicles being retired from the fleet. On balance, CO_2 damage costs per vehicle mile under given driving conditions are projected to increase from 2010 to 2030, by about 15 percent for two-axle vehicles and about 28 percent for trucks with three or more axles.

Emissions of Criteria Air Pollutants

For the 2013 C&P Report, FHWA conducted new research to enhance and update HERS' procedures for estimating economic damage costs from motor vehicle emissions of criteria air pollutants or their chemical precursors: carbon monoxide, volatile organic compounds, nitrogen oxides, sulfur dioxide, and fine particulate matter.[3] These enhanced procedures and updated values of emission damage costs replace those previously used in HERS, which were originally documented in the 2005 HERS-ST Technical Report and previously updated as described in earlier editions of the C&P report.

HERS estimates of economic damages from vehicle emissions of air pollutants were updated by first estimating new emission rates—measured in mass per vehicle-mile of travel—for criteria pollutants and their precursors. These updated estimates were developed using the U.S. Environmental Protection Agency's (EPA's) recently issued Motor Vehicle Emission Simulator (MOVES) model. Average emissions per vehicle-mile of each pollutant vary among the roadway functional classes used in HERS because the typical mix of vehicles operating on each functional class varies and different types of vehicles emit these pollutants at different rates per vehicle mile. MOVES's emission rates also vary with travel speed and other driving conditions that affect vehicles' power output.

Repeated runs of the MOVES model were conducted to develop a schedule of average emissions per vehicle mile of each pollutant by travel speed for each roadway functional class during the midpoint year of each 5-year funding period used by HERS. Because MOVES utilizes different roadway classes than HERS, the most appropriate MOVES roadway class was used to represent each HERS functional class.

HERS combines these schedules of average emissions per vehicle mile for different pollutants with estimates of the average dollar cost of health damages caused per unit mass of each pollutant to calculate damage costs per vehicle mile for each pollutant. The dollar costs per unit of each pollutant used in HERS were updated using estimates for the years 2015, 2020, 2030, and 2040 supplied by EPA; these were interpolated to produce estimates for the midpoint of each 5-year funding period.[4] HERS then adds the estimates of damage costs for individual pollutants together to calculate total air-pollution-related costs per vehicle mile at different speeds. This process resulted in updated schedules of the average dollar cost of air-pollution-related damages per vehicle mile by speed for each HERS functional class and funding period.

Motor vehicles emission rates for each criteria pollutant are projected to decline significantly in the future as new vehicles that meet more stringent emissions standards gradually replace older models in the vehicle fleet. At the same time, however, EPA projects that economic damage costs per unit of each criteria air pollutant (except carbon monoxide) will increase rapidly over time. On balance, damage costs from vehicle emissions of criteria air pollutants are projected to decline by approximately 50 percent from the present through 2030 for four-tire vehicles operating on each HERS functional class, and by 80 to 90 percent for single-unit and combination trucks.

Effects on HERS Results

Potential improvement projects evaluated by HERS can affect air pollution and CO_2 damage costs by increasing the volume of travel on a section during future funding periods, as well as by increasing the average speed of travel on that section. Higher travel volumes invariably increase emissions and damage costs, but emission and fuel consumption rates are more complex functions of travel speeds, so increasing travel speed on a sample section can cause air pollution and CO_2 damage costs to either increase or decline. Since the speed-mediated effect is often to reduce emissions, the overall effect of an improvement project on air pollution or CO_2 damage costs can go either way. Net reductions in air pollution costs represent one component of the benefits from a potential improvement to a HERS sample section, while net increases represent one component of the costs (disbenefits).

Valuation of Travel Time Savings

New research was conducted to update estimates of the value of time in HERS for use in this edition of the C&P report. Estimates of the value of time in HERS are disaggregated by type of travel (i.e., personal and business) and type of vehicle (i.e., small auto, medium auto, four-tire truck, six-tire truck, three- and four-axle trucks, four-axle combination trucks, and combination trucks with five or more axles). Values of time for both personal and business travel are specified as functions of the value of time per person hour and average vehicle occupancy (i.e., representing the sum of personal travel costs across vehicle occupants); the value of time for business travel is also a function of vehicle capital costs and the value of cargo (for combination trucks capable of carrying significant payloads). For each vehicle type, the estimate of the value of time is the weighted average across personal and business travel value of time estimates (with no personal travel represented within six-tire trucks and combination trucks).

Exhibit A-4 shows the values for each of the components of the value of travel time savings, including the aggregate cost of travel for 2010 and 2008. The updating of the values to 2010 was more comprehensive than that for 2008, and the resulting estimates were more reliable. Values for 2010 were estimated using recent data, whereas values for 2008 were based on estimates for an earlier reference year that varied across

Exhibit A-4 Estimated 2010 Values of Travel Time by Vehicle Type

2010 Travel Time Cost Elements	Travel Type	Small Auto	Medium Auto	4-Tire Truck	6-Tire Truck	3- and 4-Axle Truck	4-Axle Combination	5- or-More-Axle Combination
Value of Time per Person Hour	Business	$23.98	$23.98	$23.98	$23.98	$22.98	$22.98	$22.98
Average Vehicle Occupancy	Business	1.04	1.04	1.04	1.01	1.01	1.02	1.02
Vehicle Capital Cost per Vehicle	Business	$2.79	$3.42	$4.41	$6.22	$8.97	$8.05	$7.33
Inventory Value of Cargo	Business	--	--	--	--	--	$0.77	$0.77
Value of Time per Vehicle Hour	Subtotal	$27.73	$28.35	$29.46	$30.47	$32.23	$32.17	$31.44
Value of Time per Person Hour	Personal	$11.89	$11.89	$11.89	$11.89	$11.89	--	--
Average Vehicle Occupancy	Personal	1.38	1.38	1.61	1.61	20.20	--	--
Value of Time per Vehicle Hour	Subtotal	$16.35	$16.35	$19.16	$19.16	$272.03	--	--
Share of Personal Travel (% Vehicle Miles)		95.2%	95.2%	94.3%	0.0%	11.1%	0.0%	0.0%
2010	**Total**	**$16.89**	**$16.92**	**$19.75**	**$30.47**	**$58.80**	**$32.17**	**$31.44**
2008	**Total**	**$20.96**	**$21.00**	**$24.51**	**$29.88**	**$34.35**	**$38.32**	**$38.00**

Source: U.S. DOT Revised Guidance on the Value of Travel Time in Economic Analysis (September 28, 2011) and internal DOT estimates.

the elements in the calculations. For average vehicle occupancy and the business-purpose share of travel in four-tire vehicles, pre-2002 estimates were used. For monetary elements, reference-year estimates were updated using a relevant price deflator. For example, the entry for vehicle capital cost was updated from a 1995 reference year to 2008 using a measure of the change in average price of new motor vehicles during that period.

The value of travel time is estimated to be lower in 2010 than in 2008 for all vehicle types except six-tire trucks and the three- or four-axle vehicles. The value of travel time for six-tire trucks increased slightly because the new methodology increased the vehicle capital cost component. The value of travel time for three- to four-axle trucks increased substantially because the new methodology recognizes that some of these vehicles are actually buses, which have more occupants than trucks. Values for the other vehicle types have declined in 2010 compared to 2008 because of changes in methodology and data sources.

The value of time per person hour used in this edition follows the U.S. DOT's Revised Guidance on the Value of Travel Time in Economic Analysis, 2011. For personal travel that is local, the guidance recommends taking 50 percent of median household income divided by 2,080, which is the annual total hours worked by someone employed full-time (40 hours per week) and full-year (52 weeks). Although the guidance recommends upping this percentage to 70 percent for personal travel that is intercity, data with which to apportion personal travel between local and intercity trips is lacking. As a result, the HERS practice has been to value all personal travel following U.S. DOT recommendation for valuing personal travel that is local. For business travel, each hour is valued at the median nationwide gross wage plus fringe benefits, except for travel in trucks with three or more axles, for which the average truck driver wage is used.

Vehicle occupancy data was updated using the 2009 National Household Travel Survey (NHTS) for personal vehicles and the road freight inspection data from the Freight Motor carriers Safety Administration for freight. The estimates of average vehicle occupancy are overall lower for 2010 than for 2008. The decrease is from 1.15 to 1.04 for autos and from 1.12 to 1.02 for combination trucks. The recognition that some of the vehicles in the three- to four-axle truck category are actually buses increased average vehicle occupancy for that category significantly; although buses account for about 11 percent of the VMT of the vehicles classified as three- to four-axle trucks, they carry an average of 21.2 occupants including the driver.

The estimates of vehicle capital cost include the costs of interest and time-related deprecation, based on a 7-percent real discount rate. Time-related depreciation is based on the decline in vehicle value after the first five years of vehicle life (from the Consumer Reports Depreciation Calculator) net of the portion of this decline attributable to mileage (from HERS model calculations). The residual is the portion of depreciation that is time-related, due to vehicle aging. Data sources for the estimation of vehicle capital costs included the Energy Information Administration's Annual Energy Outlook, the 2009 NHTS, and 2002 Vehicle Inventory and Use Survey. The estimates of vehicle capital cost have increased in 2010 relative to 2008 for autos and small trucks and declined for trucks with three or more axles. The estimated value of cargo declined from $0.82 per hour in 2008 to $0.77 per hour in 2010. The inventory value of cargo represents the hourly financial carrying cost of holding inventory in transit. The estimate of the inventory value of cargo was found by assuming an interest rate of 7 percent and vehicle use of 2,000 hours per year, and applying these values to estimates of average weight of truck cargo (44,800 pounds, as calculated using the 2007 Commodity Flow Survey from the Bureau of Transportation Statistics) and average shipment value per pound (as calculated from the total value of shipments and total ton-miles carried by truck, also from the 2007 Commodity Flow Survey), with prices adjusted to 2010 dollars.

Endnotes

[1] The VII program at U.S. DOT has evolved into the Connected Vehicle Program: http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm. As of this writing, for HERS the strategy enabled by VII technologies is advanced traveler information. Additional strategies covered under the Connected Vehicle program have not been incorporated.

[2] The chemical properties of fuels were obtained from Wang, M.Q., GREET 1.5 — Transportation Fuel-Cycle Model: Volume 1, Methodology, Use, and Results, ANL/ESD-39, Vol.1, Center for Transportation Research, Argonne National Laboratory, Argonne, Ill., August 1999, Table 3.3, p. 25 (available at http://greet.es.anl.gov/index.php?content=publications&by=date&order=up#Technical_Publications).

[3] Fine particulate matter now includes only particles up to 2.5 microns in diameter and is often referred to as PM2.5 for that reason. This revised definition excludes most or all components of road dust and particles produced by brake and tire wear. The main components of PM2.5 are sulfate, nitrate, and other particles formed by chemical reactions in the atmosphere from gaseous tailpipe emissions.

[4] For a description of these estimated damage costs, see: U.S. EPA and National Highway Traffic Safety Administration, Joint Technical Support Document, Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, August 2012, pp. 4-42 to 4-48 (available at http://www.nhtsa.gov/fuel-economy).