The Highway Economic Requirements System (HERS): How HERS Works

presented to

Committee for a Study of the Future Interstate Highway System

presented by

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What We’ll Accomplish Today

- Provide an overview of the HERS model for application to the Future Interstate Study
- Explain why it was created and how it has been used
- Discuss its strengths and limitations
- Offer some approaches to overcoming limitation
The Modeling Dilemma

“Essentially, all models are wrong, but some are useful.”
~ George Box

- All models have similar limitations makes their ability to perfectly predict the future tenuous, but are useful for:
  - Control and isolate factors that only rigorous experimental designs can identify
  - Comparison of the relative merits of different treatments
HERS Overview

- Created to assist FHWA in a variety of policy studies, especially the recurring *Conditions and Performance Report* to Congress; also used by several states for future needs analysis.
- Essentially a model that simulates how agencies would invest in highways on a benefit/cost basis.
- Tests what the cost and performance impacts are of those investments over time.
  - Based on current and predicted deficiencies based on state-reported inventory and travel.
  - Tallies costs and performance implications of making (or not making) investments.
HERS: Types of Investments

- Pavement surface
- New capacity – more lanes
- Cross-section – grades, curves, and shoulders
- Operations strategies – incident management, ramp metering, advanced signal control, active traffic management
HERS: Performance Categories

Primary Performance Measures:
- Pavement Surface Condition
- Traveler Delay and Travel Time Reliability
- Crashes
- VMT

Secondary Performance Measures:
- Vehicle Operating Costs
- Fuel Consumption
- Emissions

Make an Improvement?

Degrade Performance

Upgrade Performance

NO

Yes
Highway Performance Monitoring System (HPMS): The Data Engine Behind HERS

- Roadway inventory data collected and submitted by the states
  - Mostly the same data the states use for their own planning

- Full Extent vs. Sample Panel
  - 23,600 miles vs. 46,900 Interstate miles covered in the Sample Panel used by HERS (50% coverage)

- Data are reported by relatively short highway sections
HPMS Data Types

- Shoulder
  - Lanes

- Median
  - HOV Lanes

- Shoulder

- Pavement Surface Condition
- Traffic Count
- Truck Count
- Traffic Forecast
- Tolls
- Tolls
HERS: High Level Program Flow

Initial Setup: HPMS Base Year

Deficiency “Screening”
Including “Not Deficient”

Define Alternate Improvements
Including “Do Nothing”

Project Evaluation with B/C Analysis

Estimate Impacts

Select Preferred Alternative

Aggregate Costs and Performance to System

Summarize and Report for Analysis Year

Benefits
• Travel Time
• Vehicle Operating
• Crash
• Maintenance
• Emissions

Costs
• Initial Improvements

HERS Performance Sub-Models

Cost Savings
HERS: Submodels for Performance

- Use many of the same procedures that are used by agencies for planning studies, but tailored to fit the available data and national scope of HERS

- Pavement surface condition
  - Data for the new pavement equations: HPMS dataset plus default data tables from Mechanistic-Empirical Pavement Design Guide (MEPDG)
  - Also uses internal forecasts of cracking, faulting and rutting in the estimation of future IRI
HERS Submodels (cont.)

- Speed and delay
  - Based on latest Highway Capacity Manual procedures for travel time reliability
  - Includes the effects of queuing

- Crashes
  - Based on Highway Safety Manual procedures, using the pure prediction models rather than the model/crash data approach taken by the HSM
  - Many default values assumed
HERS Submodels (cont.)

- Emissions and fuel consumption
  - Based on EPA’s MOVES model but many default values are needed

- Vehicle operating costs
  - Fuel consumption
  - Oil consumption
  - Tire wear
  - Maintenance and repair
  - Depreciable value
HERS: Strengths

- National in scope
  - Same data and procedures used for all states

- Data and technical procedures very similar to what states and MPOs would use for their own needs analyses

- Provides insight into the tradeoffs between investment and performance
  - Used successfully in other studies ("Bottom Line")
HERS: Strengths

Consider modeling a starting point – results to be interpreted through multiple lenses

» Agency practices
» Noncovered impact areas
» New technologies (automated vehicles)
HERS: Limitations

- Works on independent HPMS roadway sections
  - Real projects tend to be much longer and encompass multiple types of treatments

- Bottlenecks: a crude approximation
  - Based on capacity of a basic freeway segment
  - Interchanges are the worst bottlenecks but neither the data nor analysis procedures are available
    - Lack of interchange configuration also an issue for truck size and weight
HERS: Limitations

- Considers pavement *surface* condition only
  - Problems/aging with entire pavement structure ignored

- Limited number of improvement types
  - Many safety improvements not considered
  - Demand management
HERS: Limitations

- HERS is NOT a travel demand model
  - No network on which to “flow” demand estimation
  - Traveler response to improved/worsening conditions handled by simple elasticities

- HPMS traffic forecasts not specific to a highway section
  - Supposed to be generalized growth rate from a travel demand model for a region…
  - But also can be derived from trends or statewide VMT forecasts

- Truck counts and peaking factors also based on generalized data
What Kind of Results Can Be Attained?

Average Annual Investment Modeled in HERS (Billions of Dollars)

VMT on Roads with Good Ride Quality, Percent

Assuming Trend VMT Growth

Assuming Trend VMT Growth
What Kind of Results Can Be Attained?

Average Annual Investment Modeled in HERS (Billions of Dollars)

Percent Change in Delay from Base Year

Total Delay

$30.0 $40.0 $50.0 $60.0 $70.0 $80.0 $90.0

-40% -30% -20% -10% 0% 10% 20% 30%

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How to Avoid the Black Box Syndrome

- Externally identify trends and test them within HERS
  - Use selected case studies to document various futures.
  - Set alternative improvement types, default values and parameters for testing
    - Example: Pavement Health Track (PHT) models, which specifically include a maintenance cost model to account for service life extensions associated with various pavement preservation treatments
How we plan to use case studies to inform the models

Case Studies

Input data from case study into model

Model inputs

Model calculation

Model outputs

Results from case study

Do model outputs match case study results?

Yes

Model is ready to use

No. Go back and tweak the model

Modeling process
How to Avoid the Black Box Syndrome

- Use HPMS and state-derived data outside of HERS
  - Extract key algorithms from HERS
  - Example: Bottleneck analysis

- When in doubt, do sensitivity analysis
  - Many factors could influence results, both exogenous (VMT, new technologies) and endogenous (algorithms and default data)
How to Avoid the Black Box Syndrome

- Examine how states and MPOs are conducting their own needs analyses and planning for the future of their Interstates
  - Potentially glean from desk audit style case studies
  - 20-25 year time horizon most likely
  - Tap pavement, bridge, freight and safety plans and management systems
  - Consider and test demand forecasts in use
  - Consider other investment rationales used by agencies not accounted for in models such as Sustainability, Livability, and Economic Progress