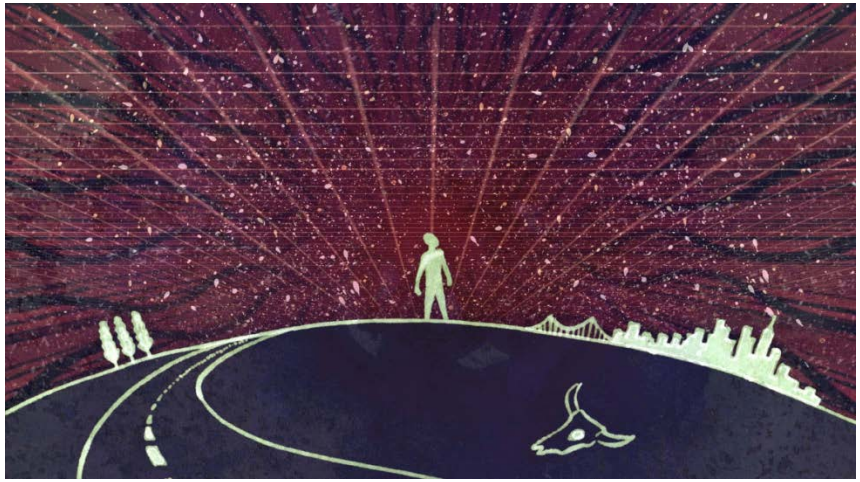
The Yellow Brick Road:

What Economics Has to Do with Pavements and How HERS-ST Paves the Way.

Nathaniel Coley,
FHWA

Agenda

- Why this Presentation
- Fundamentals of ROI Analysis
- HERS-ST ROI Model
- HPMS-Data in HERS-ST



The Question Was posed

What in the Hell does Economics have to do with pavements?

“We’re off to see the Wizard!” on Solid Gold Roads

Or Maybe just as impractical, Stainless Steel Roads

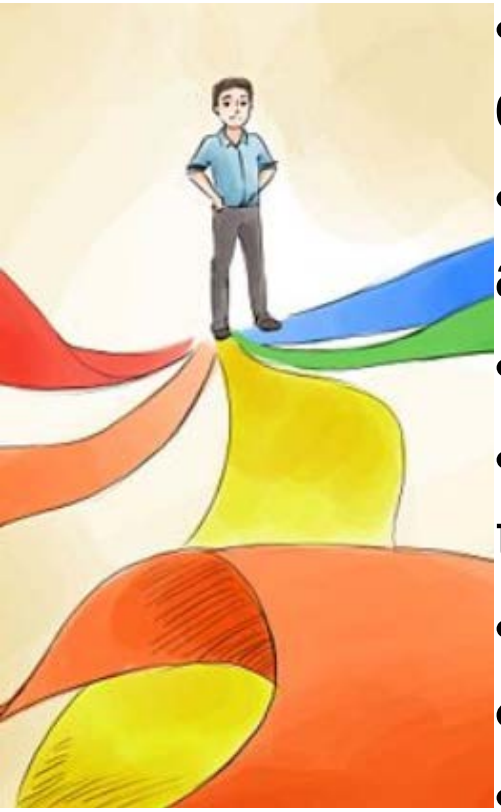
If it wasn't for economic considerations we could have stainless steel roads

Let's Start with a Few Insane Ideas

Fundamentals of Economic (ROI) Analysis

Our Role in Transportation

Transportation Decision Makers pursue various objectives based of traffic forecasts and trends. These include:



- **Safety** – Reducing fatalities, injuries, & property damage
- **Infrastructure Condition** – maintaining roads and bridges in good condition
- **Congestion** – reducing congestion
- **System Reliability** - improve the efficiency of traveling
- **Freight movement** - improve freight networks & support economic development
- **Environmental Sustainability** - protecting and enhancing the natural environment

The Role of Economic Analysis

- Each consideration has specific performance metrics that decision makers use:

Safety – # of fatalities, # of injuries by severity, & Value($) of property damaged

Infrastructure Condition – IRI, cracking, rutting, cracking %, Bridge Sufficiency Rating, Health Index, Life-cycle costs($) of building and maintaining

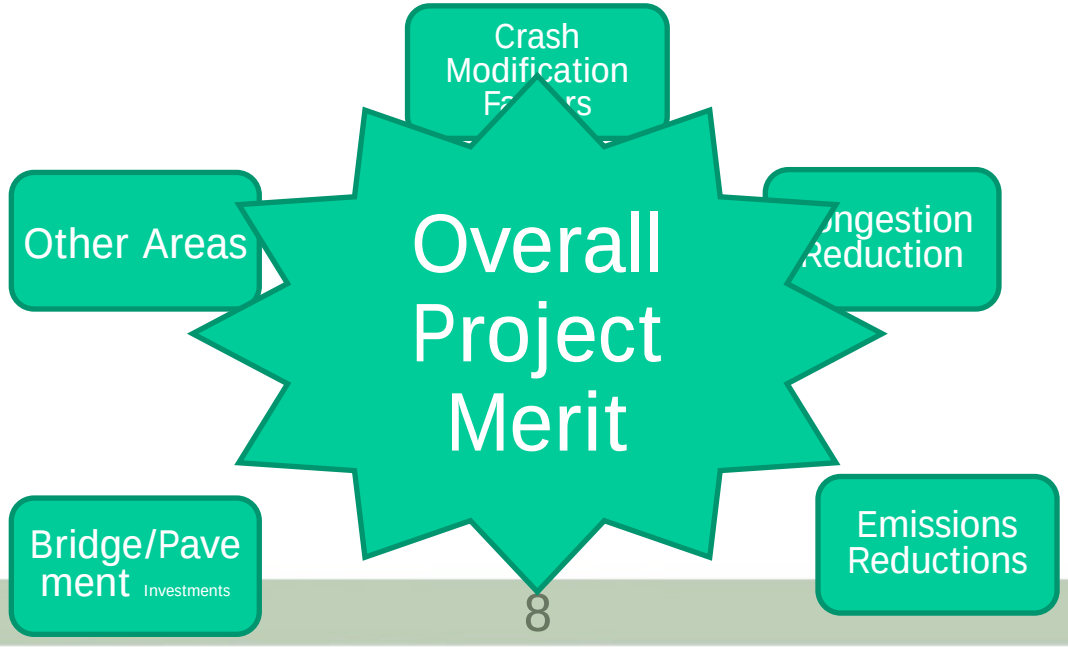
Congestion & System Reliability – delay, costs of congestion,

Freight movement and Economic Vitality – Delay, Costs to businesses

Environmental Sustainability – amount of pollution emitted, impacts on the human and natural environment

Fundamentals of Economic Analysis

- Decision makers responsible for different areas make decisions individually, but we implement projects that span focus areas.
- We need to evaluate investment decisions considering all factors



Fundamentals of Economic(ROI) Analysis

- We should evaluate investments the same way we evaluate designs
- Choose investments based on characteristics of traffic flows:
  - ADTs
  - Types of Vehicles
  - Volume/capacity
  - Forecasts
- To compare ROI of alternative designs, we need to be able to compare all of these quantitatively

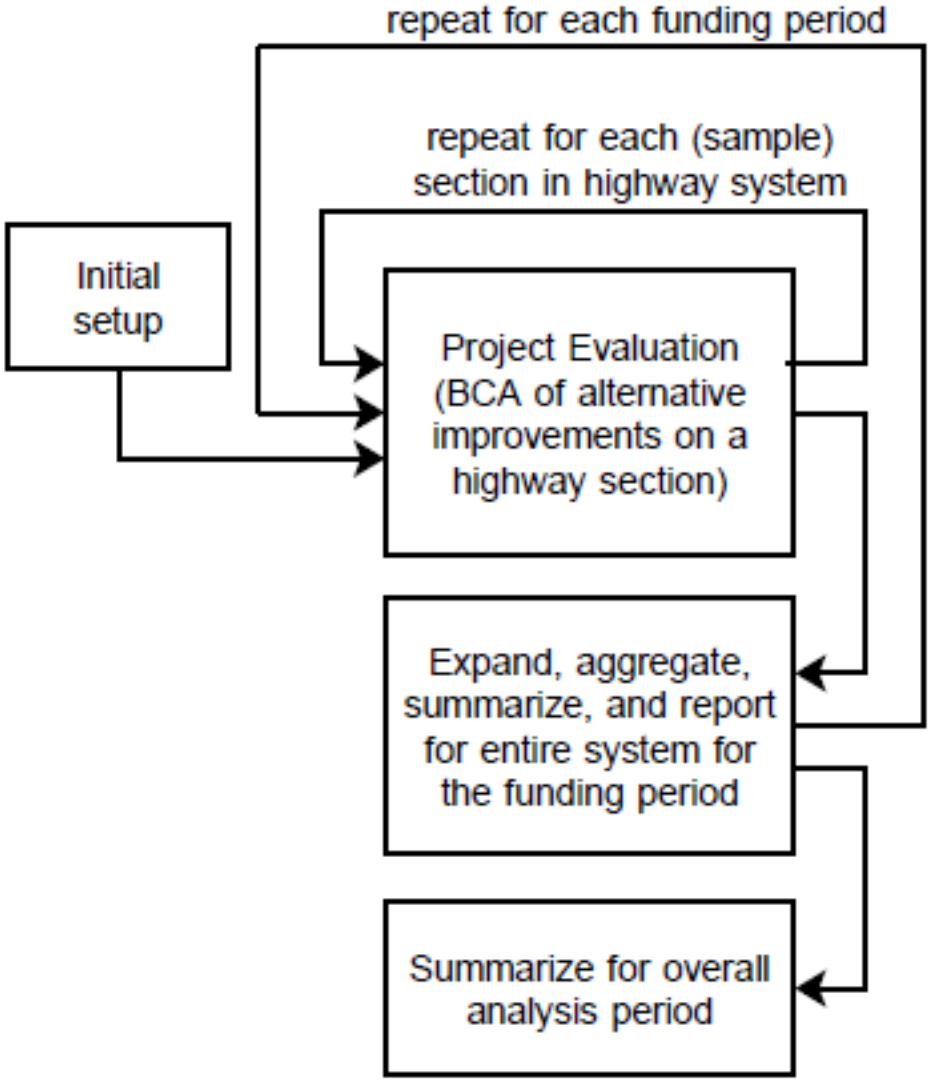
Fundamentals of Economic Analysis

Analyzing Transportation Decisions
Build a Program or Plan

	Benefit / Cost Ratio	Safety ROI	Life-Cycle Costs	Environmental ROI	Net-Benefits ROI
Overall Project Merit	7.3	$2.3m -234 serious injuries Avoided	$5.1mil	$3.1m Or Metric Tons NO_x	$6.5Mil
Overall Project Merit	2.1	$2.1m -182 serious injuries Avoided	$7.1mil	$7m Or Metric Tons CO2	$10.4Mil
Overall Project Merit	.03	$1.7m -137 crashes Avoided	$6.1mil	$1.9m Or Metric Tons NO_x	$8.3Mil
Overall Project Merit	-2	-$.3m 69 crashes additional	$2.1mil	$5.3m Or Metric Tons VOCs	-$1.3Mil

HERS-ST Analysis Process

HERS-ST analysis each highway section individually to allocate funds section by section. The result is a group of projects that optimize system(network) performance. Only projects that benefit the system(network) gets funds.



HERS-ST Analysis out of the Box

1. "Constrained Funds"

   Select improvements subject to specified budget constraints

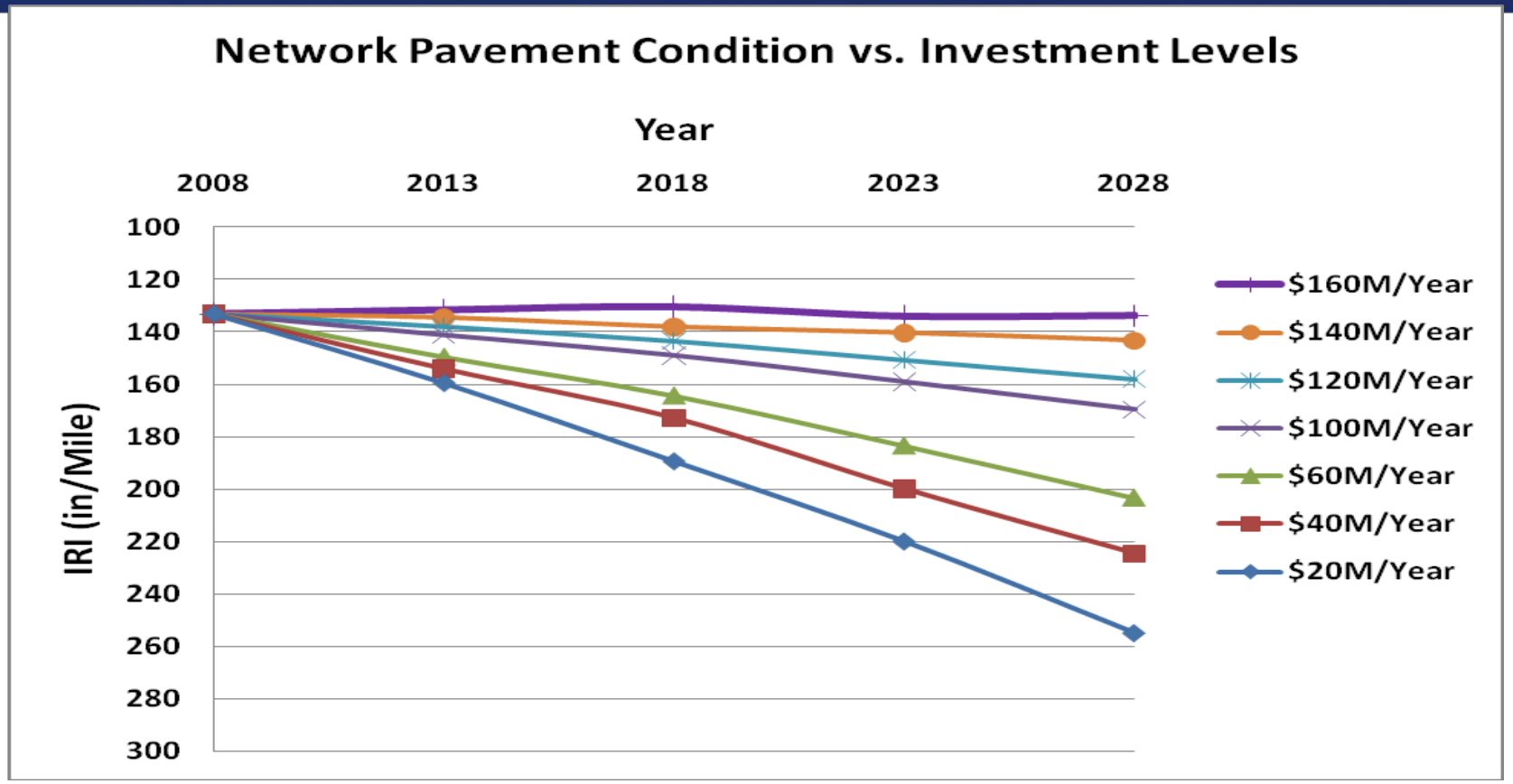
2. "Maintain Conditions"

   Find level of expenditures necessary to maintain some condition (e.g. Pavement Performance) at current level

3. "Economic Efficiency"

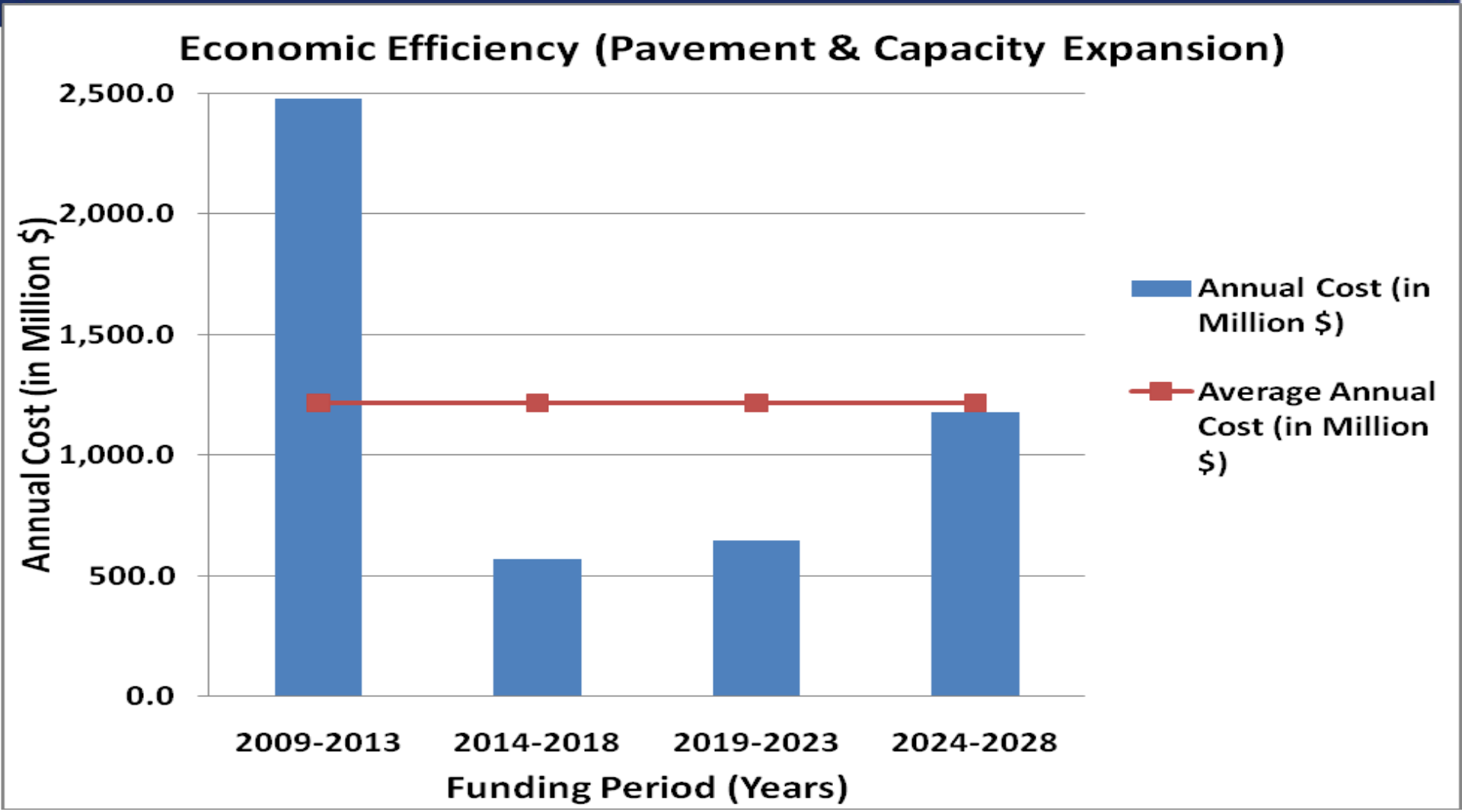
   Implement all where present discounted value of future benefits exceeds cost of improvement

Network Pavement Condition vs. Investment Levels



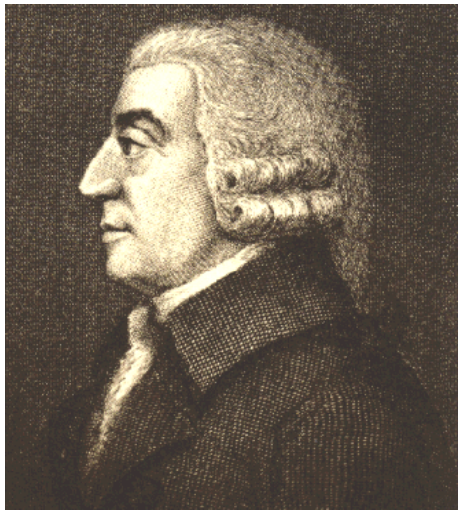
Min $160M/yr (purple line) over the next 20 years to maintain the existing network pavement condition.

How much do we need to build all cost beneficial projects?



The Role of Economic Analysis

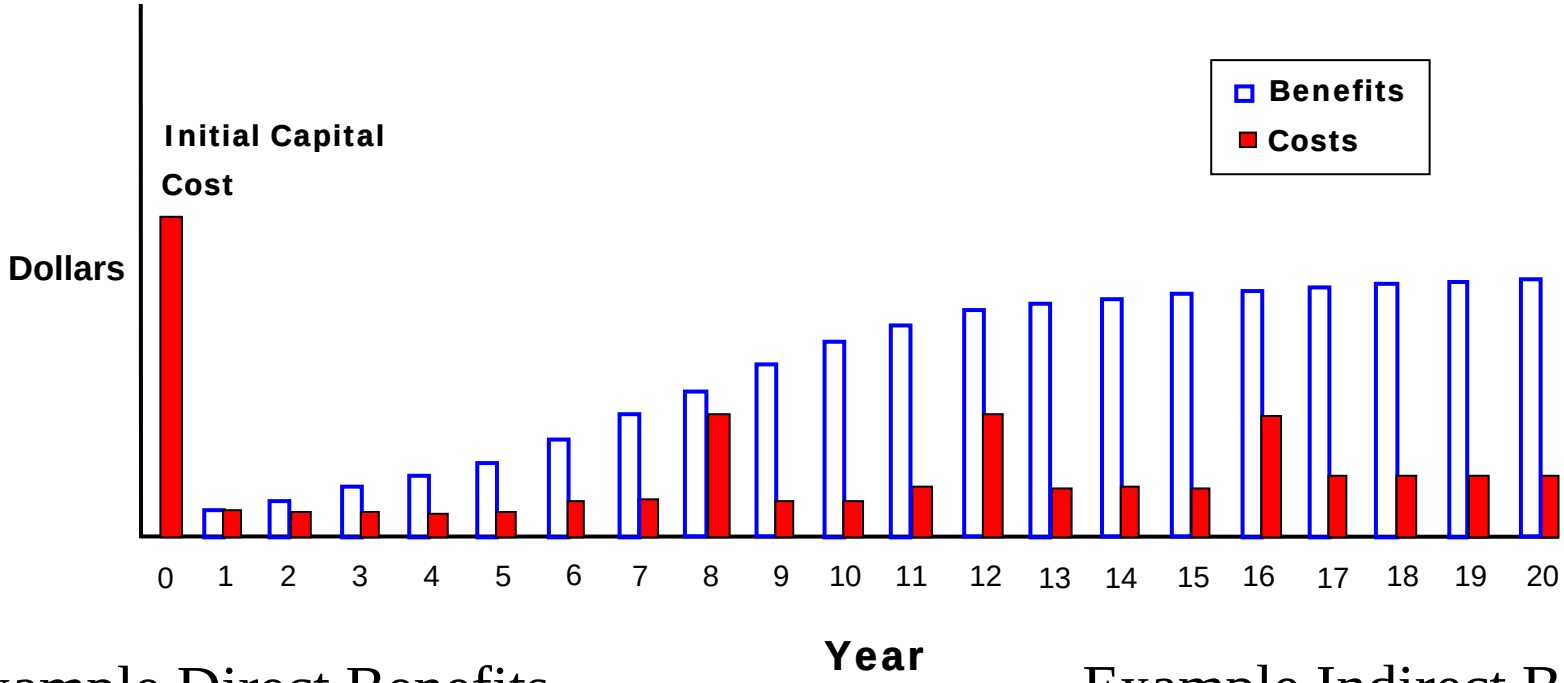
- Mechanism for monetizing, evaluating and comparing long-term benefits and costs of alternatives
- Economic analysis results
  - Help structure project and program level tradeoffs
  - Quantify & Qualify costs and benefits to the agency and to roadway users
  - Support repeatable and transparent project justification and prioritization
- We will be discussing Benefit Cost Analysis(BCA)
- Does not provide THE decision. It provides a logical framework to support decisions



Adam Smith

Life-Cycle Comparisons

Typical Life-Cycle Profile



Example Direct Benefits
- Reduced Accident Costs
- Reductions in Delay Costs
- Reduced noise or emissions

Example Indirect Benefits
- Land use impacts
- Employment
- Non-user benefits

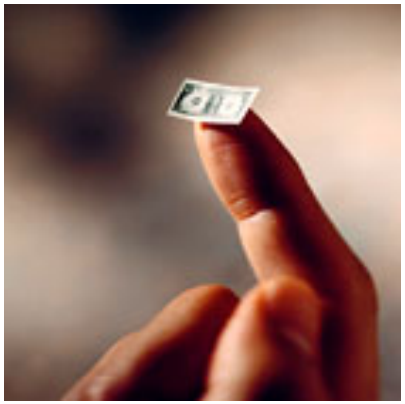
Life-Cycle Comparisons

Dollar Now vs. Dollar Later

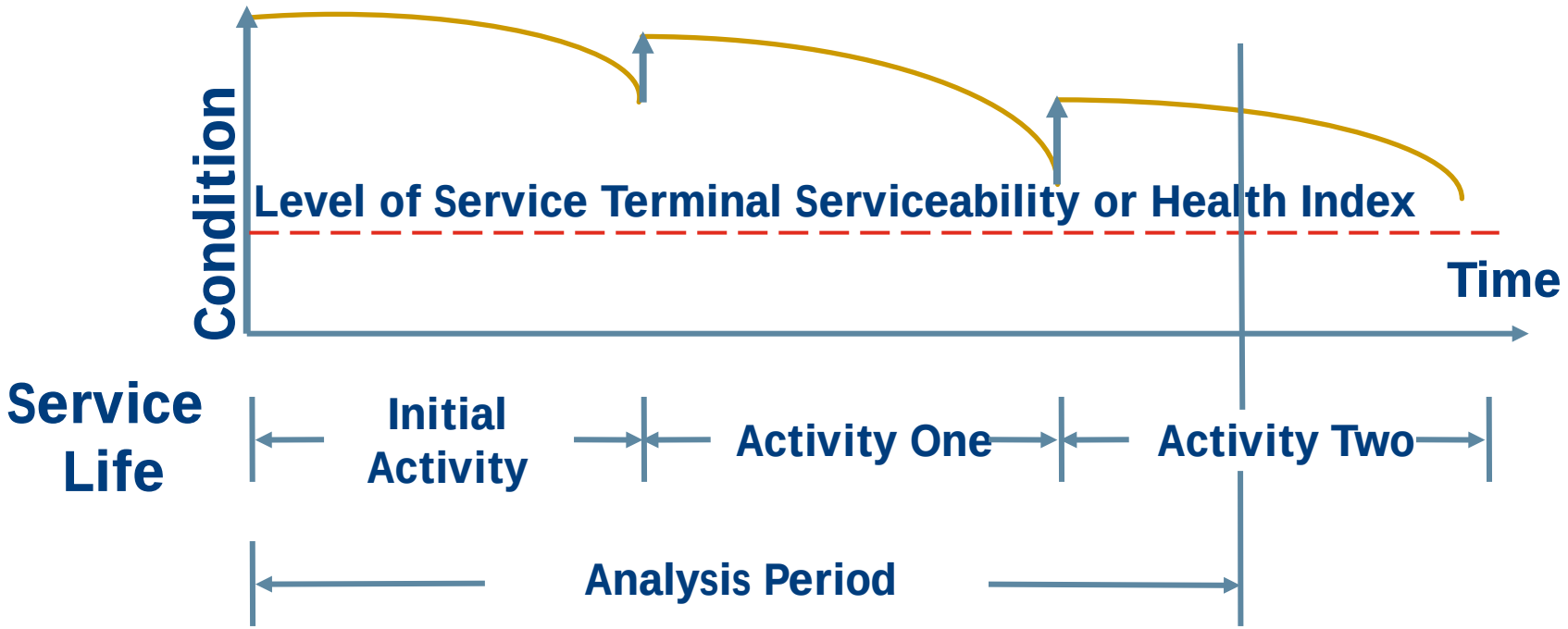
Two separate and distinct factors account for why the value of a dollar, as seen from the present, diminishes over time

- Inflation

- Time value of a dollar(Discounting)

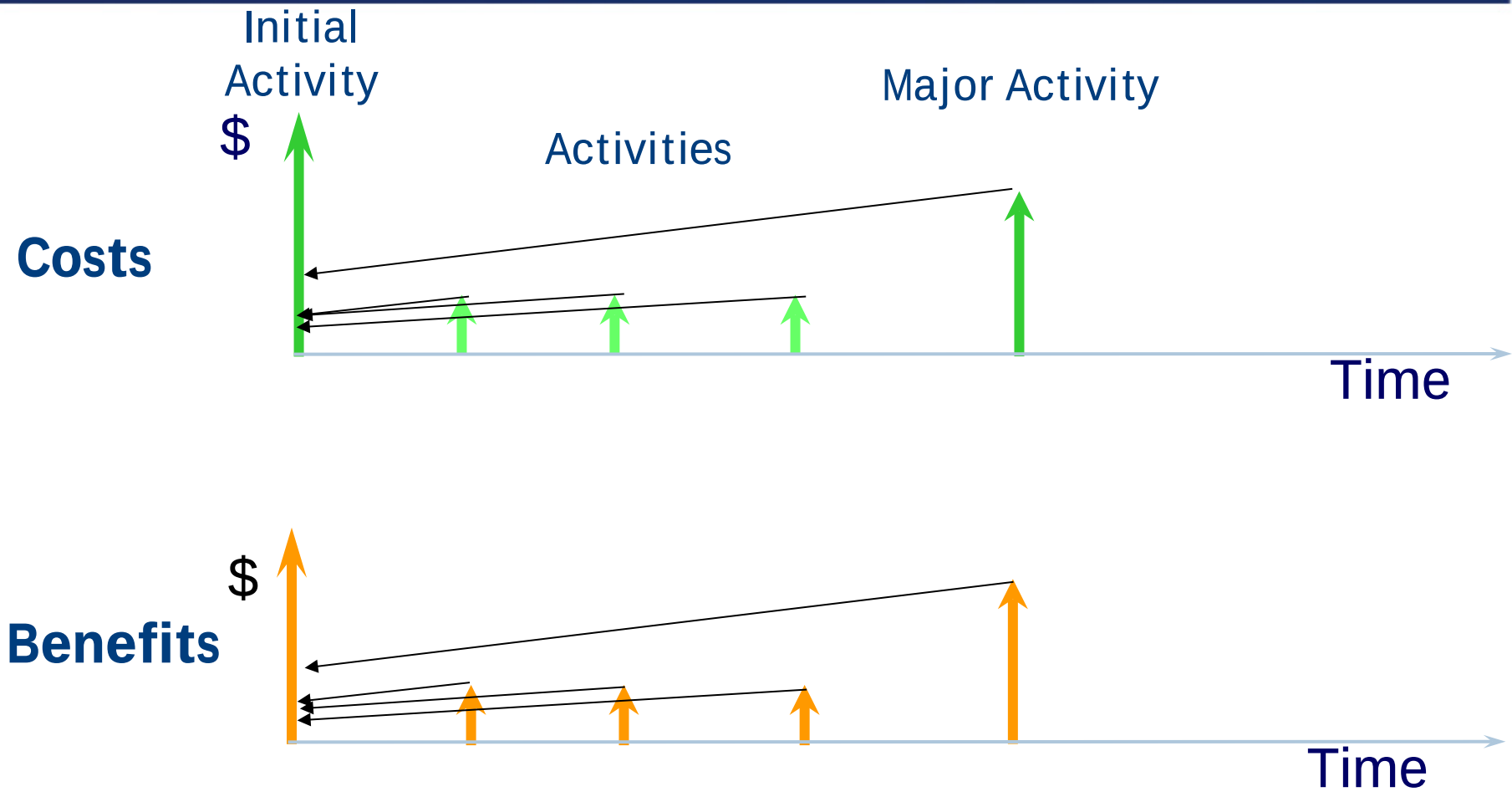


Life-Cycle Comparisons



When will the future deterioration countermeasures be required?

Calculate Present Values of Costs and Benefits



What is the present value of future sums?

Benefit Cost Analysis

- Benefit Cost Analysis - the comparison of benefits over time & of costs over time for proposed projects. BCA is a tool used to aid in public investment decision making by measuring the return on investment(ROI) of spending from the viewpoint of net benefit to society.

  ~ *NCHRP 8-36, Task 62*

- BCA is different from financial analysis, which focuses on how to fund a project (e.g. Once you know "What" you want, you can decide what you can afford)

HERS-ST Benefit and Cost Elements

- Agency Costs
  - Design and Engineering
  - Land Acquisition
  - Construction
  - Reconstruction/Rehabilitation
  - Preservation/Maintenance
- User Cost/Benefit
  - Delay/Time Saving
  - Crashes/Avoided Crashes
  - Vehicle Operating Costs
- Externalities
  - Air Quality

HERS-ST Roadway User Costs Components

Definition

Costs to highway users over the life of a Highway Project

Components

- **Delay Costs** – Costs associated with an increase (or decrease) in the amount of time it takes for a user to travel from point A to B based on changes in Speed, signals, curves, grades, pavements cond.

- **Vehicle Operating Costs** – Costs attributable to the operation or maintenance of a vehicle(maint./ repair, fuel consumption, depreciation, etc.)
- **Crash costs**-Cost resulting from property damage, injuries, or loss of life

HERS-ST Environmental Cost Calculations

- Cost of emissions of air pollutants Based on MOBILE5a and PART5

  (Two other EPA Emissions Modeling Software)
- Emissions per mile varies with

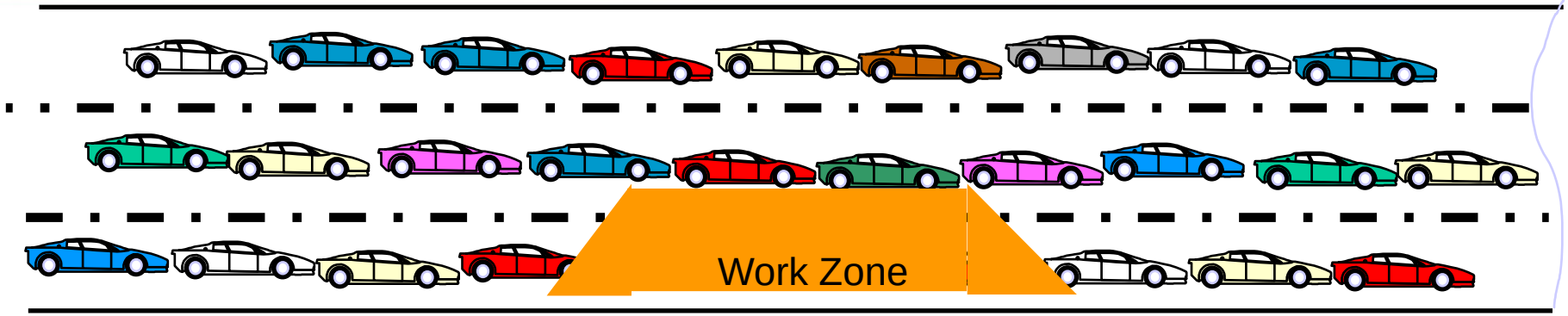
  Vehicle class (3 classes)

  Roadway functional system

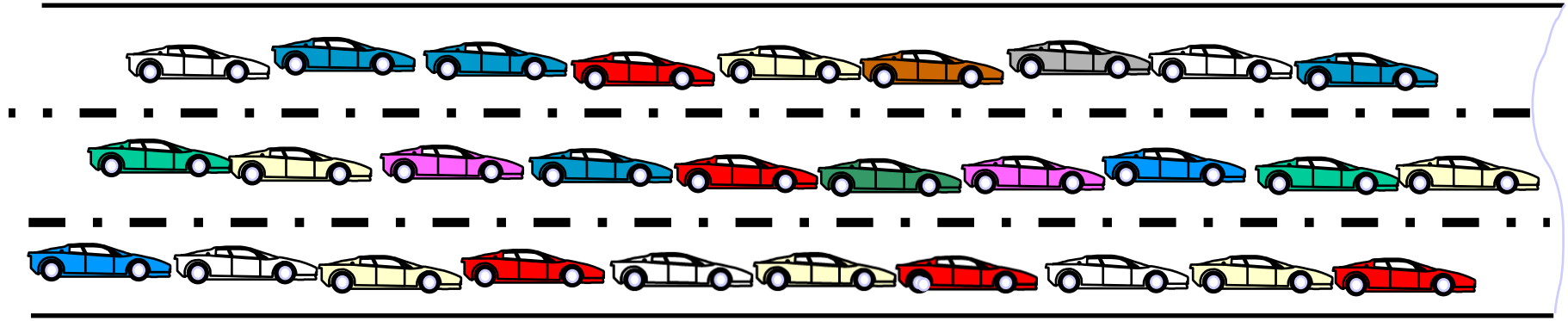
  Average speed

  Calendar year

Understanding Costs Related to Roadway Capacity

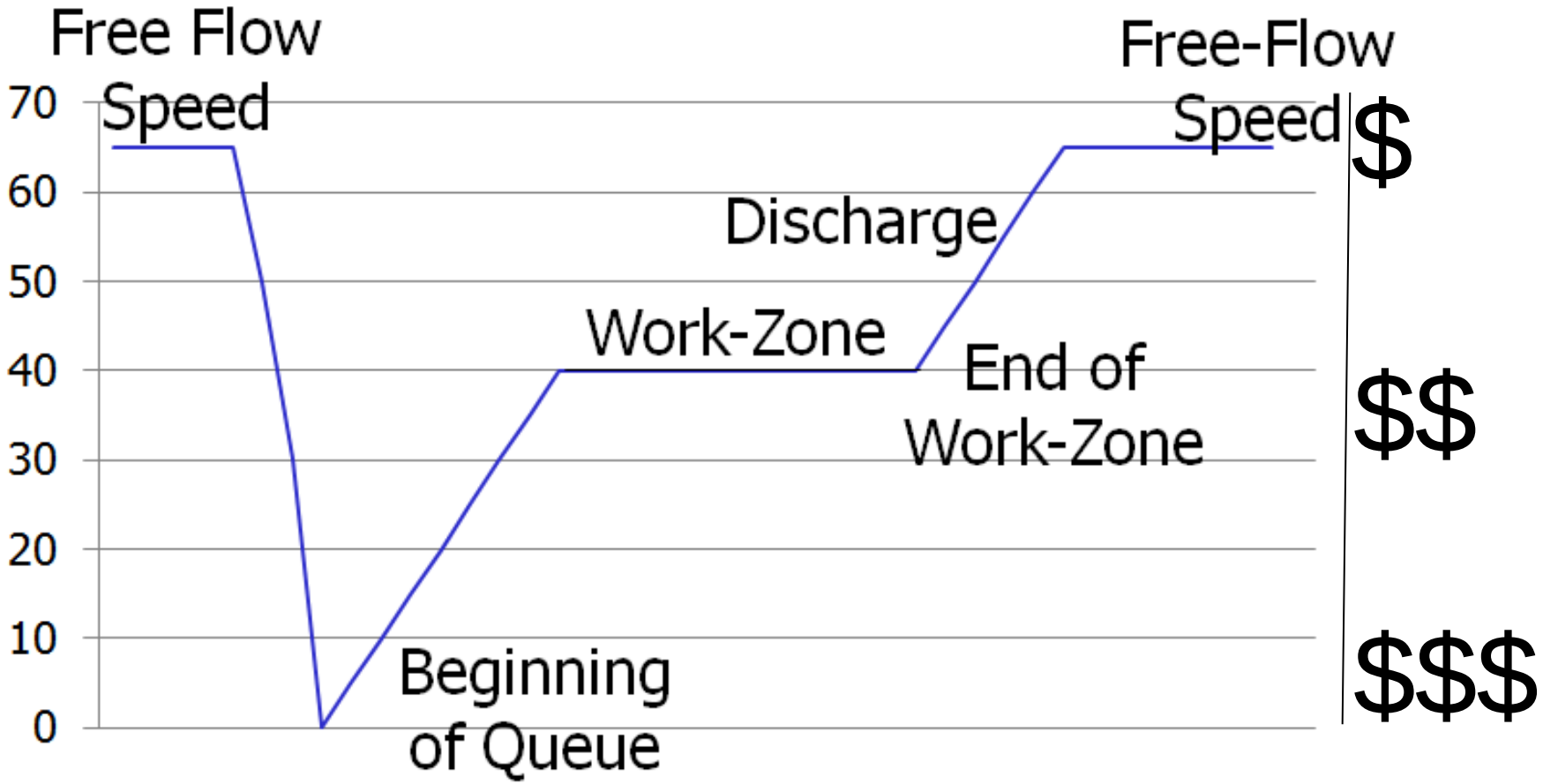


1. Existing Costs on construction Route(Pre-WZ)
2. Additional Costs from WZ



1. Existing cost on detour route(Pre-WZ)
2. Additional Costs of detoured traffic on Detour Route

Conceptual Work-Zone impact on travel speed



Pavement Management System V.S. HERS-ST

According to the Asset Management NPRM, a Pavement Management System:

(1) Collects, processes, stores, & updates inventory and condition data;

(2) Forecasts deterioration

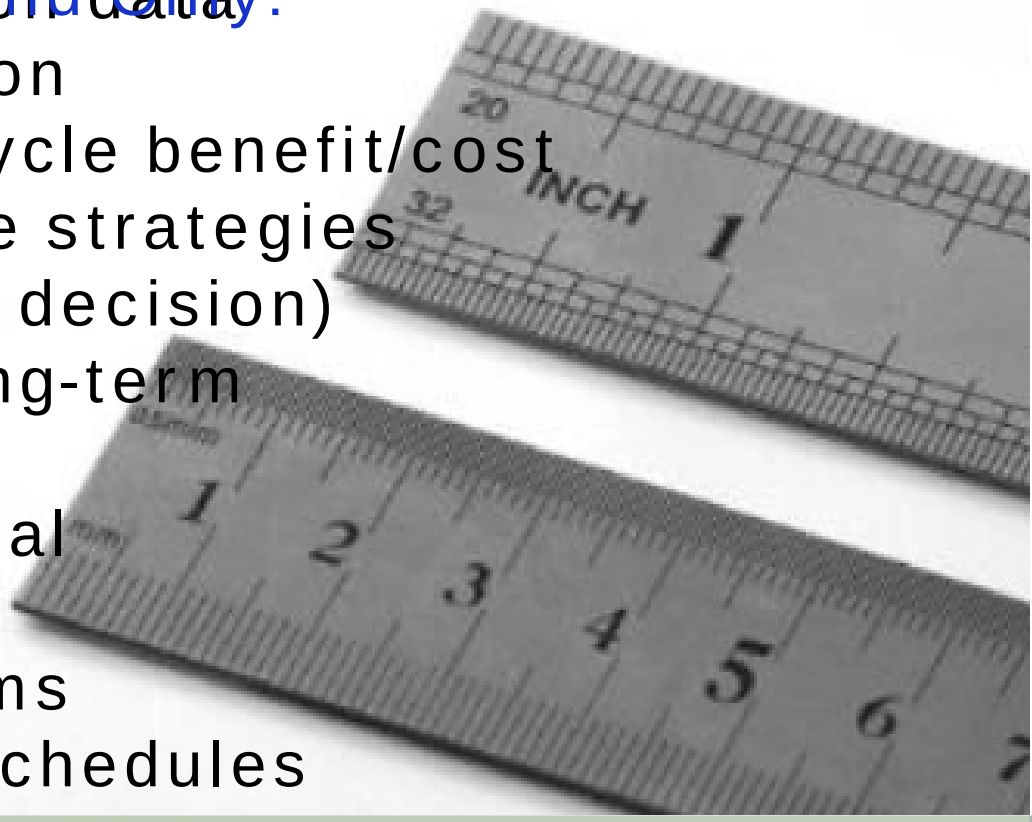
(3) Determines the life-cycle benefit/cost analysis of alternative strategies (including a no action decision)

(4) Identify short- and long-term budget needs

(5) Determines the optimal strategies

(6) Recommends programs and implementation schedules

Since States already Collect, process, store, & Update inventory and condition data in the HPMS Data Set which was just discussed, HERS-ST on the other hand Only:

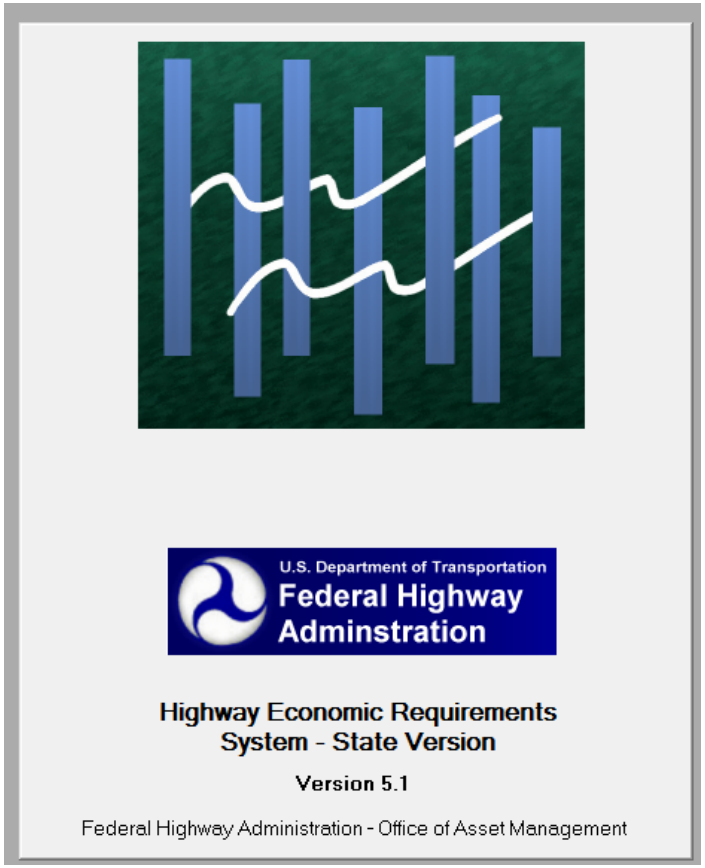


HERS and HERS-ST

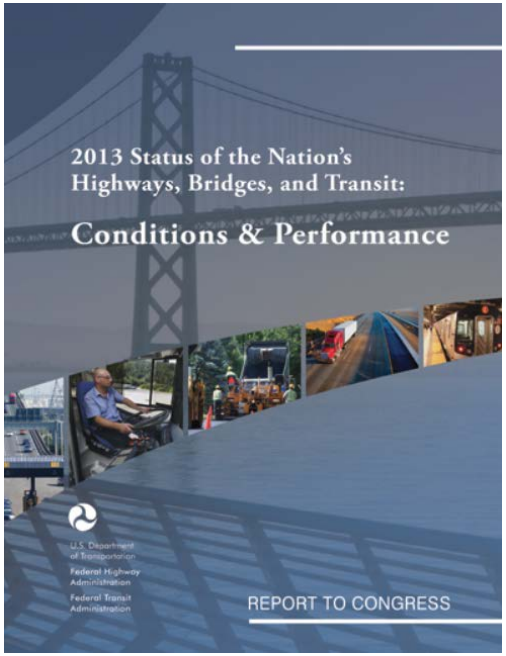
FHWA Supports 2 Version of HERS Software

I. National HERS Software

II. HERS-State



I. HERS (or National HERS)

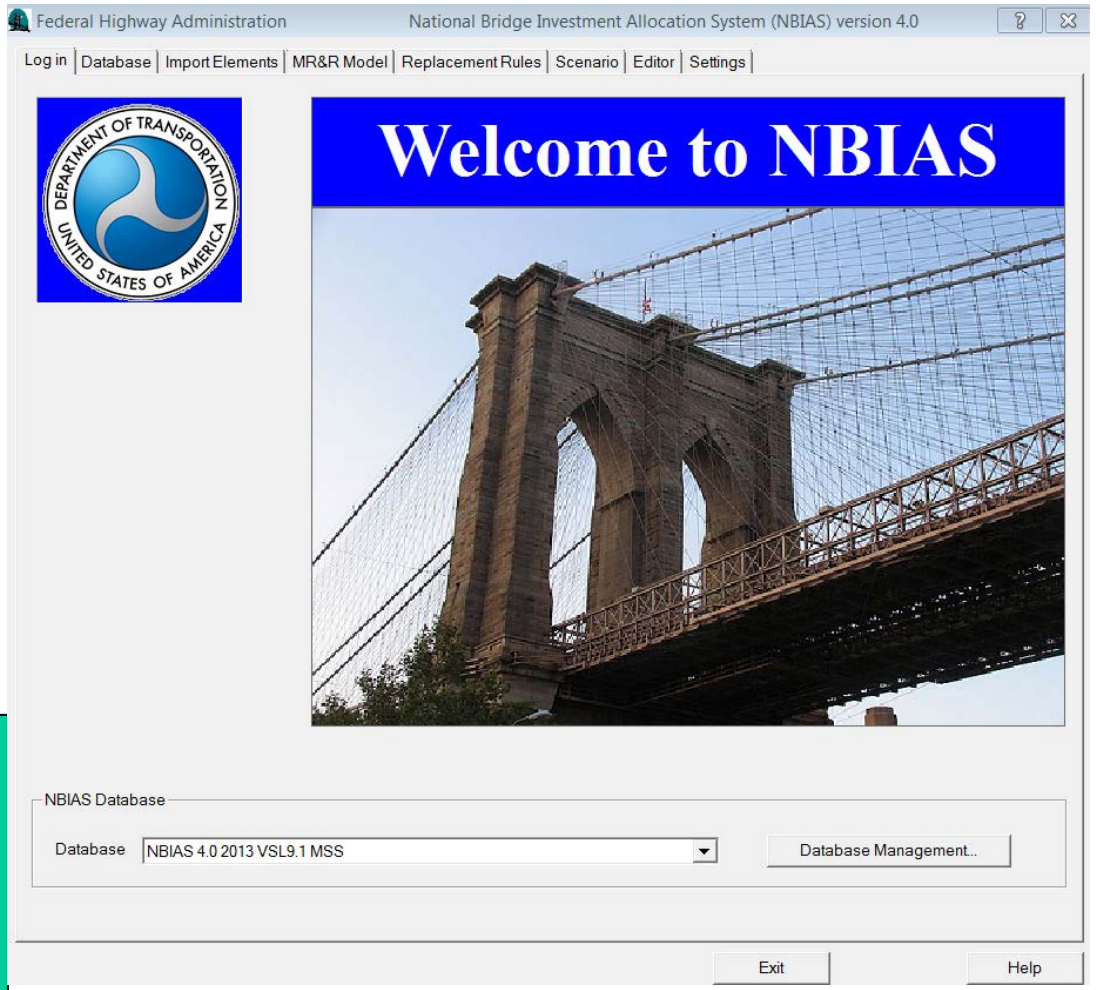


- Developed 1988-1991 for FHWA
- Text Based
- Continually Supported
- Primary use – highway needs analysis for FHWA's *Conditions and Performance Report to Congress*

Oh by the way!

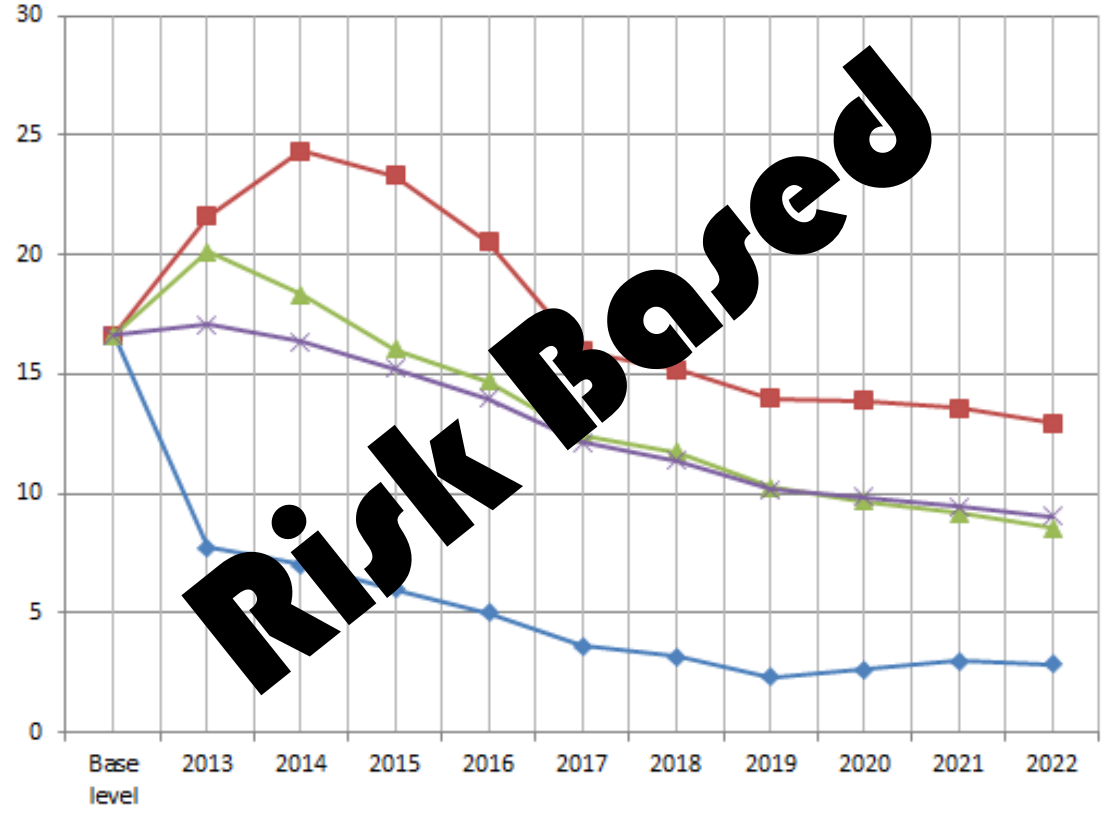
FHWA also supports the National Bridge Investment Analysis System (NBIS) that uses NBI data already collected by States.

See Agenda for my poster session and presentation on it.



A program of projects that would make progress toward State targets

Deck area percentage of structurally deficient bridges



- Unconstrained budget
- Budget $202M/year + 3% annual increase
- Flat budget of $305M/year
- Front-loaded budget, $600M in first year, then $240M annually

II.HERS-ST

- Developed 2000-2002 for FHWA
- Has 2 components
  1. HERS-ST “Engine”
     modified version of National HERS
  2. Graphical User Interface (GUI)

Changes to National HERS get migrated to HERS-ST

HERS-ST – Potential Uses

- Highway Needs (Investment Requirements)
- Investment/Performance Relationships
- Corridor Planning
- State Transportation Plans
- Highway User Cost Analysis
- Budgeting Process
- Endless Possibilities on ODOT Website

http://www.oregon.gov/ODOT/TD/TP/Pages/CM_HERS.aspx

Data

HERS-ST uses HPMS condition Data that every state collects

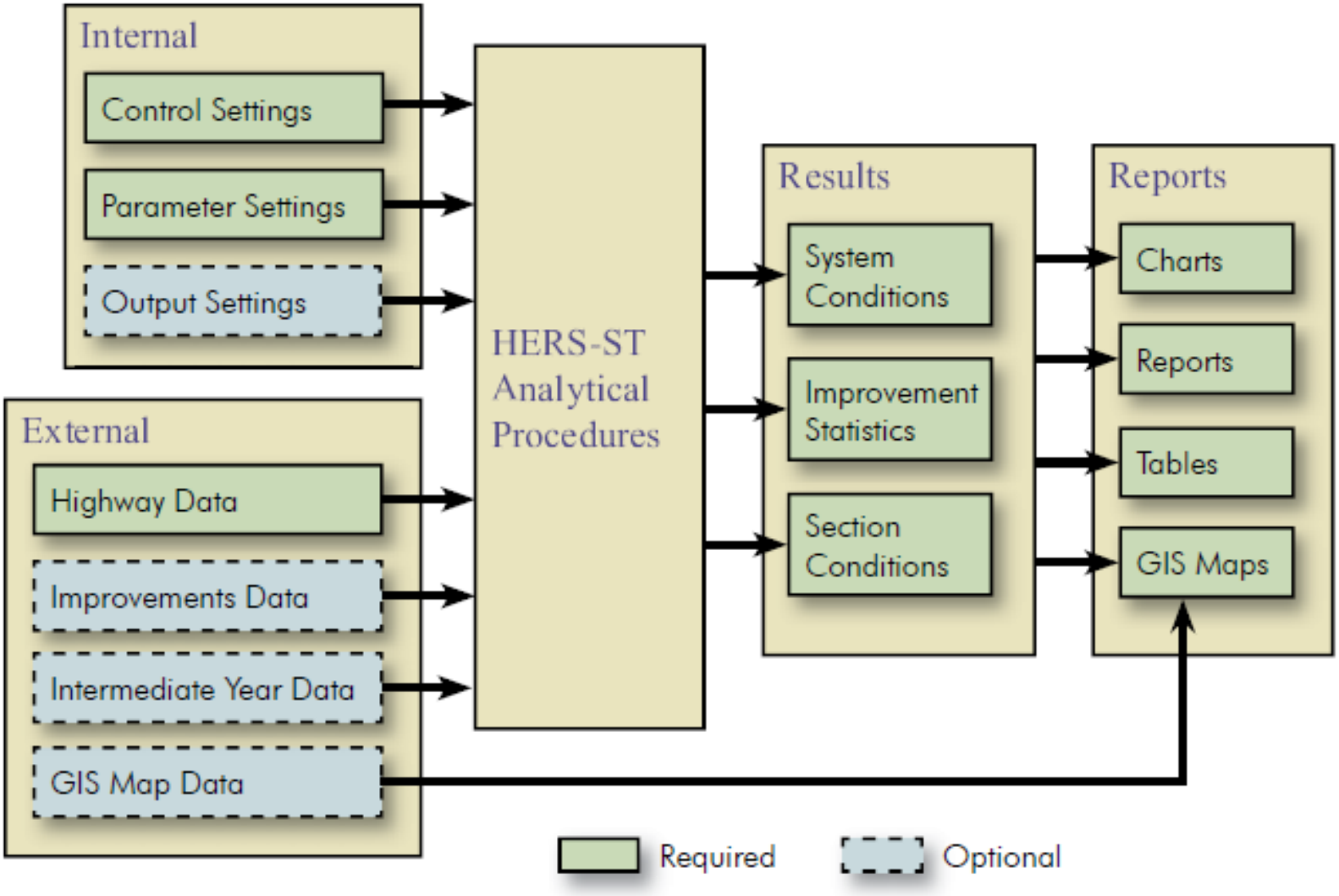
Table 6-1. HPMS Data Items (shaded blue indicates not used by HERS-ST)

Item No.	Data Item	Data Type
1	Year of Record	Numeric; Integer
2	State Code	Numeric; Integer
3	Route Identifier	Character Field
4	Begin Point	Numeric; Decimal
5	End Point	Numeric; Decimal
6	Section Length	Numeric; Decimal
7	Functional System	Numeric; Codes
8	Urban Code	Numeric; Integer
9	Facility Type	Numeric; Codes
10	Structure Type	Numeric; Codes
11	Access Control	Numeric; Codes
12	Ownership	Numeric; Codes
13	Through Lanes	Numeric; Integer
14	HOV Type	Numeric; Codes
15	HOV Lanes	Numeric; Integer
16	Peak Lanes	Numeric; Integer
17	Counter Peak Lanes	Numeric; Integer
18	Right Turn Lanes	Numeric; Codes
19	Left Turn Lanes	Numeric; Codes
20	Speed Limit	Numeric; Integer
21	Toll Charged	Numeric; Codes
22	Toll Type	Numeric; Codes
23	Route Number	Numeric; Integer
24	Route Signing	Numeric; Codes
25	Route Qualifier	Numeric; Codes
26	AADT	Numeric; Integer
27	AADT, Single Unit Trucks	Numeric; Integer
28	Peak Percent, Single Unit Trucks	Numeric; Integer
29	AADT, Combination Trucks	Numeric; Integer
30	Peak Percent, Combination Trucks	Numeric; Integer
31	K Factor	Numeric; Integer
32	Directional Factor	Numeric; Integer
33	Future AADT	Numeric; Integer
34	Future AADT Year	Numeric; Integer
35	Signal Type	Numeric; Codes
36	Percent of Green Time	Numeric; Integer
37	Number of Signals	Numeric; Integer
38	Number of Stop Signs	Numeric; Integer
39	Number of Other Controls	Numeric; Integer
40	Lane Width	Numeric; Integer
41	Median Type	Numeric; Codes
42	Median Width	Numeric; Integer
43	Shoulder Type	Numeric; Codes
44	Right Shoulder Width	Numeric; Integer
45	Left Shoulder Width	Numeric; Integer
46	Peak Parking	Numeric; Codes
47	Widening Obstacle	Character Field
48	Widening Potential	Numeric; Integer
49	Curve Class A	Numeric; Decimal
50	Curve Class B	Numeric; Decimal
51	Curve Class C	Numeric; Decimal
52	Curve Class D	Numeric; Decimal
53	Curve Class E	Numeric; Decimal
54	Curve Class F	Numeric; Decimal
55	Terrain Type	Numeric; Codes
56	Grade Class A	Numeric; Decimal
57	Grade Class B	Numeric; Decimal
58	Grade Class C	Numeric; Decimal
59	Grade Class D	Numeric; Decimal
60	Grade Class E	Numeric; Decimal
61	Grade Class F	Numeric; Decimal
62	Percent Pass Sight	Numeric; Integer
63	IRI	Numeric; Integer
64	IRI Year	Numeric; Integer
65	IRI Month	Numeric; Integer
66	PSR	Numeric; Decimal
67	Surface Type	Numeric; Codes
68	Rutting	Numeric; Decimal
69	Faulting	Numeric; Decimal
70	Cracking Percent	Numeric; Decimal
71	Cracking Length	Numeric; Decimal
72	Year of Last Improvement	Numeric; Integer
73	Year of last Construction	Numeric; Integer
74	Last Overlay Thickness	Numeric; Decimal
75	Thickness, Rigid	Numeric; Decimal
76	Thickness, Flexible	Numeric; Decimal
77	Base Type	Numeric; Codes
78	Base Thickness	Numeric; Decimal
79	Climate Zone	Numeric; Codes
80	Soil Type	Numeric; Codes
81	County Code	Numeric; Integer
82	NHS	Numeric; Codes
83	Future Facility	Numeric; Codes
84	STRAHNET Type	Numeric; Codes
85	Truck Route	Numeric; Codes
86	VSF	Numeric; Decimal
87	Capacity	Numeric; Integer
88	Design Speed	Numeric; Integer
89	Vertical Alignment	Numeric; Codes
90	Horizontal Alignment	Numeric; Codes
91	Volume Group	Numeric; Codes
92	Expansion Factor	Numeric; Decimal

Example Analysis

- Overall analysis period is divided into several "funding periods" (FPs) – typically 5 years long
- In each Funding Period, HERS –
  - Identifies potential improvements for a section
  - Forecasts conditions with/w-out the improvement
  - Estimates discounted net benefits of each improvement
  - Uses incremental benefit-cost analysis to recommend a program of improvements

HERS-ST Analysis Process



Pavement Deterioration Modeling

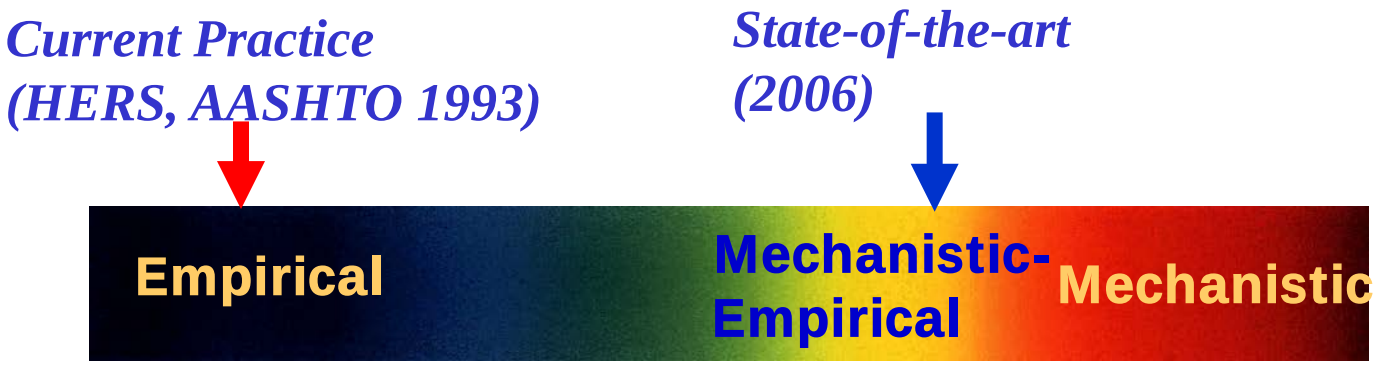
Mechanistically calculate pavement response (i.e., stresses, strains, and deflections) due to:

- Traffic loading
- Environmental conditions

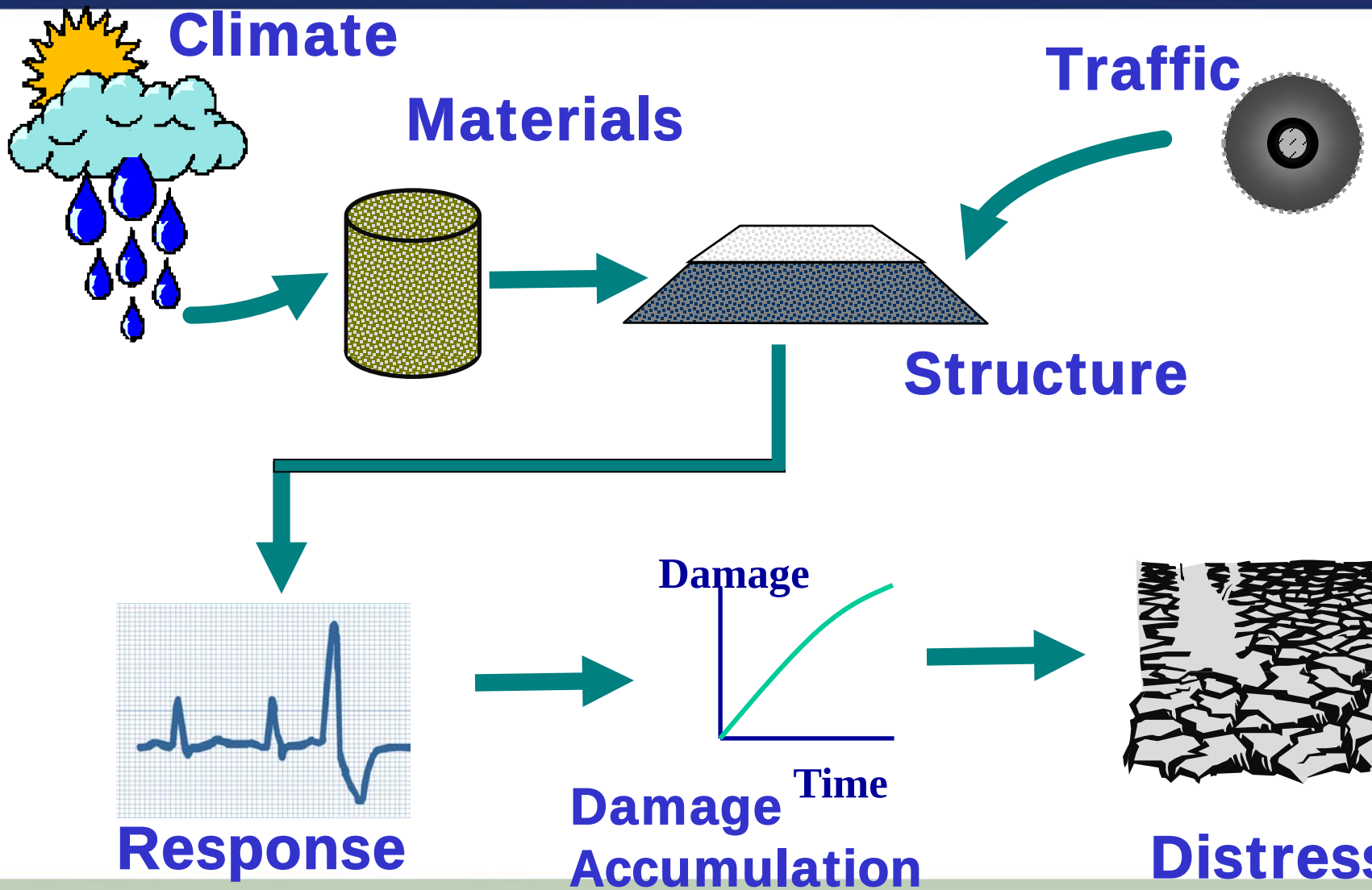
Accumulate *damage* over time

Empirically relate damage over time to pavement distresses (e.g., cracking, rutting, faulting)

Calibrate predictions to observed field performance



Pavement Deterioration Modeling



HERS-ST Improvement Types

Pavement

- Resurfacing
- Pavement reconstruction

Widening

- Shoulder improvements
- Widen lanes
- Add normal-cost lanes
- Add high-cost lanes

Alignment

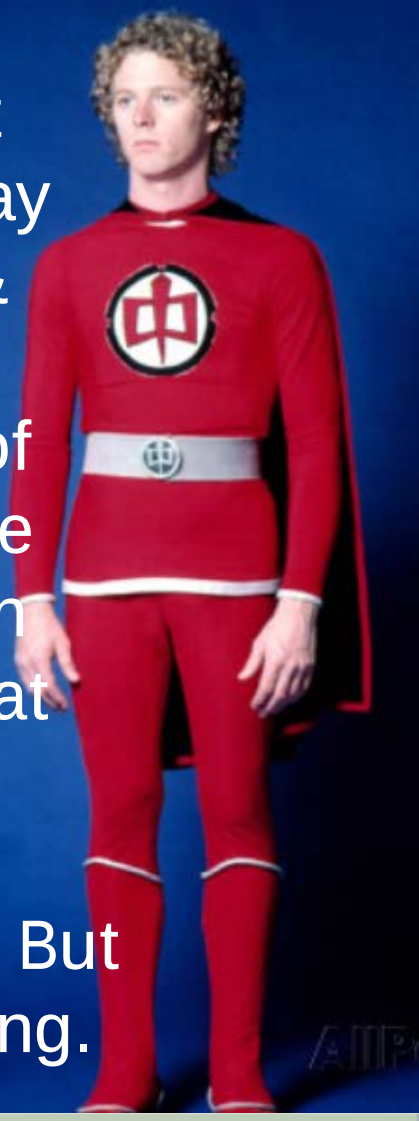
- Improve horizontal and/or vertical alignment

Can't See the Forest Because of the Trees

Can Someone Move these Roads?
I need to Manage my System

Why would I use HERS-ST if I already do the same thing?

If you perform an analysis that spans forecasted pavement deterioration using a robust pavement deterioration model, apply the latest TRB Highway Capacity Manual Speed and capacity equations & other algorithms, incorporate well established economic reasoning & values, for every section of pavement on your network and then compare the long-term ROI of investing in each section & then rank each investment & then assemble a plan that manages your assets to make progress toward targets, your budget, efficiency, or maintaining current conditions, you should not use HERS-ST. But even if you do all of this, there is still programming.



The Role of the Programming Wizard…(To Be Continued)

The Role of the Programming Wizard

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