The Future of Pavement Technology

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University of Washington

Topics

- Design tools
- Infrastructure costs and lives
- Transportation R&D
- Pavement-related training
- Road infrastructure and alternative uses
- Concluding thoughts

Big Questions for this Era
(at least a selection of big questions)

- How much do we need to budget for maintenance/preservation of pavements?
- Are we spending enough on R&D?
- How can we improve training?
- Can highways become utilities?

What will not be discussed

- MEPDG
- Warm Mix Asphalt
- Ultra Thin Anything
- etc

What is really important about future pavement technology?

- Work should be done on important topics that truly alter pavements and how they serve the public:
  - Funding
  - Life
  - Energy

Design Tools

Pavement Design Tools

- Is the availability of new, improved pavement design tools important?
- No matter what your answer, more tools are on the way and some will be easy to use.
- Let's look at one from SHRP2 R-23 "Using Existing Pavement in Place and Achieving Long Life."

SHRP 2 R23

Long Life Pavement Design Guidelines

v1.0 beta

Steps: 1 — 2 — 3 — 4 — 5

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Pavement Assessment

A review of the assessment process requires your concurrence which is located at the bottom of this page.

Broadly, pavement assessment involves an examination of the existing roadway. Data is collected and analyzed to determine the characteristics and condition of the existing structure. This information is then plotted versus longitudinal distance along the lane. Based on critical areas of distress and other structural factors, the length of the project is typically divided into smaller homogenous sections.

Once the roadway is sectioned using the process above, a subset of "critical sections" is selected that will dominant the overall renewal process. From this set of critical sections, a primary candidate section is selected to perform extended analysis to determine the appropriate renewal strategy.

☐ I have read the introduction to long life pavement guidelines and understand the use of this application.

GET STARTED

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Enter Section Information

Description | Existing | Proposed

Number of through lanes: 1 one-direction

Pavement Type:

Number of layers*:

*Includes type, thickness & date constructed. Four layers max. Subgrade automatically

Layer	Type	Depth (in)	Date constructed
1		1	
2		0	
3		0	
4		0	

Cross Section

Subgrade

PREVIOUS NEXT

Resources

- Project Assessment Manual
- Construction Productivity and Traffic Impacts
- Life Cycle Cost Analysis
- Preservation Considerations for Long Life Pavements
- Life Cycle Assessment
- Emerging Pavement Technologies

Download Report

Click button to download the Project Assessment Manual

Project Assessment Manual

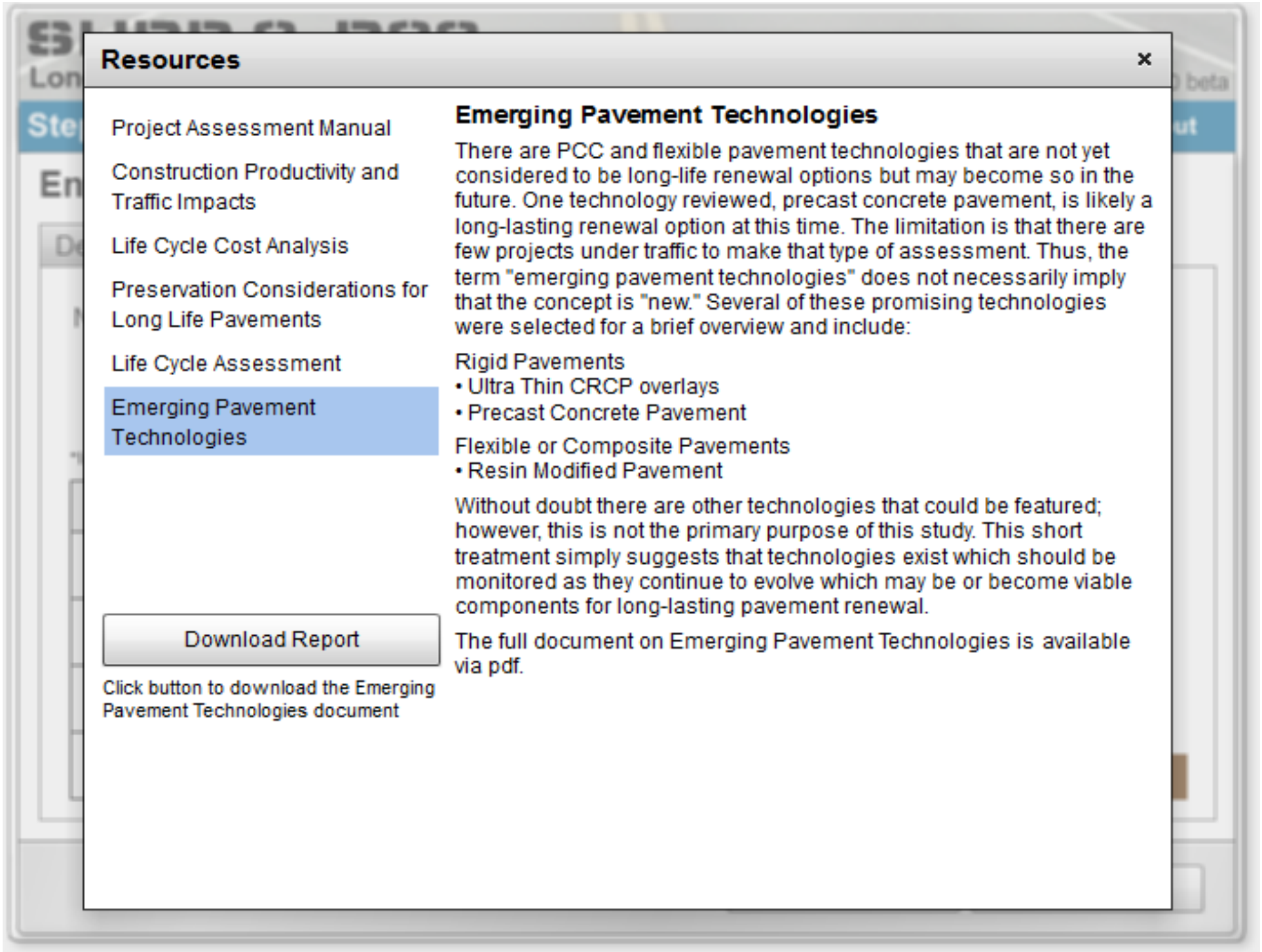
The Project Assessment Manual (PAM) was prepared to aid the process of renewing existing pavements so that long lives can be achieved. To achieve this goal a systematic collection of relevant pavement-related data is needed. Further, such data needs to be organized to maximize the usefulness in pavement decision-making process. To that end, this manual will help.

The types of data collection described in the manual range from basic information such as a distress survey to insights on construction-related traffic impacts. The last section in the PAM provides information on life cycle assessments (environmental accounting). This type of assessment is receiving increasing use and is likely to be widely applied in the future.

The use of the manual is to compliment the design tools developed by the SHRP2 R23 study. The types of data critical for making pavement-related decisions are described along with methods (analysis tools) for organizing the information for decision-making. It is not assumed that all data categories will be collected or assessed for a specific renewal project.

There are 10 data types contained in this manual. These are:

- Pavement distress surveys
- Pavement rut depths and roughness
- Nondestructive testing—Falling Weight Deflectometer
- Ground Penetrating Radar
- Pavement cores
- Dynamic Cone Penetrometer
- Subgrade soil sampling and tests
- Traffic loads for design
- Construction productivity and traffic impacts
- Life cycle assessment


Resources
Project Assessment Manual
Construction Productivity and Traffic Impacts
Life Cycle Cost Analysis
Preservation Considerations for Long Life Pavements
Life Cycle Assessment
Emerging Pavement Technologies
Download Report
Click button to download the Emerging Pavement Technologies document
Emerging Pavement Technologies
There are PCC and flexible pavement technologies that are not yet considered to be long-life renewal options but may become so in the future. One technology reviewed, precast concrete pavement, is likely a long-lasting renewal option at this time. The limitation is that there are few projects under traffic to make that type of assessment. Thus, the term "emerging pavement technologies" does not necessarily imply that the concept is "new." Several of these promising technologies were selected for a brief overview and include:
Rigid Pavements
• Ultra Thin CRCP overlays
• Precast Concrete Pavement
Flexible or Composite Pavements
• Resin Modified Pavement
Without doubt there are other technologies that could be featured; however, this is not the primary purpose of this study. This short treatment simply suggests that technologies exist which should be monitored as they continue to evolve which may be or become viable components for long-lasting pavement renewal.
The full document on Emerging Pavement Technologies is available via pdf.

Ultra Thin CRCP

Ultra Thin CRCP

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Enter Section Information

Description | Existing | Proposed

Number of through lanes: 1 one-direction

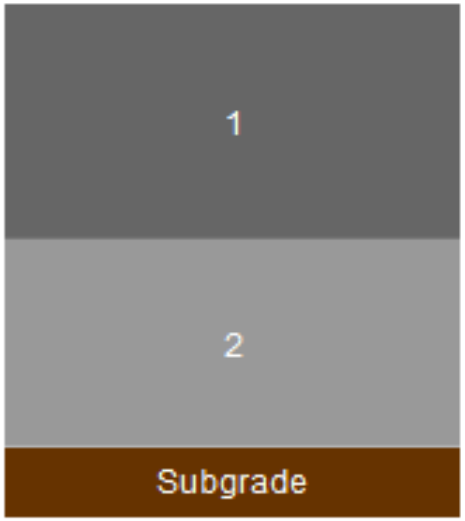
Pavement Type: Flexible

Number of layers*: 2

*Includes type, thickness & date constructed. Four layers max. Subgrade automatically

Layer	Type	Depth (in)	Date constructed
1	HMA	9	1977
2	Granular Base	8	1977
3		0	
4		0	

Cross Section



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Existing Pavement Condition

- [ ] FATIGUE CRACKING
- [ ] PATCHING
- [ ] RUTTING
- [x] TRANSVERSE CRACKING
- [ ] STRIPPING

TRANSVERSE CRACKING

Number of cracks 2 /100 ft.

Reset Save

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Select Renewal Strategy

1. Renewal type option: Flexible

2. Select a Recommended Action

Action	Description
Full depth renewal	Pulverize pavement structure full-depth followed by a thick AC overlay.
Full depth renewal	Pulverize and treat residual material with emulsion or foamed asphalt resulting in a treated base.

3. Select an Existing Pavement or Base Modulus

30000 psi

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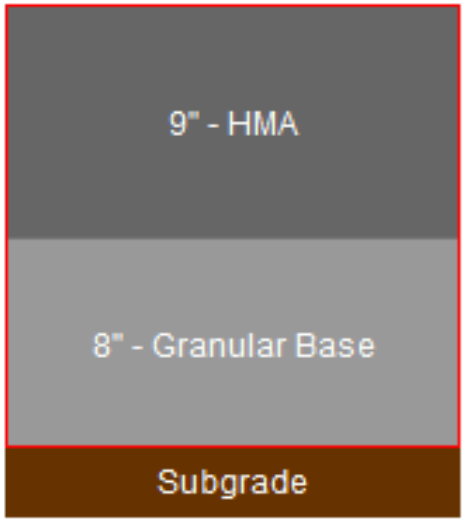
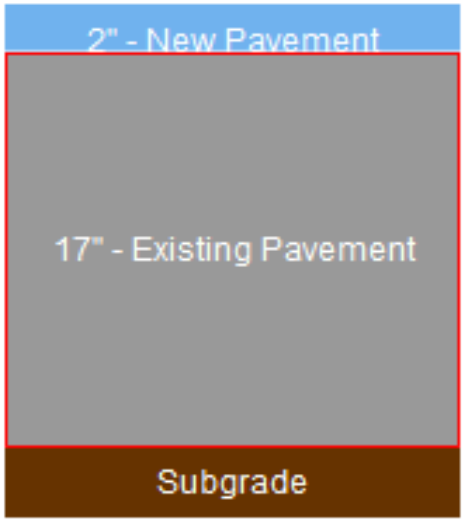
Section Summary

Renewal Design | Best Practices | Guide Specs

Existing



Proposed



Recommended Design

Renewal Type: Flexible

Design Period: 50 years

Design ESALs: 19 million

Subgrade MR: 10000 psi

Preexisting Pavement or Base Modulus: 30000 psi

Actions:

Pulverize pavement structure full-depth followed by a thick AC overlay.

Pavement Removed: 0"

Existing Pavement: 17"

Estimated Total Design Thickness: 11.0"

New Pavement: 2"

Added Elevation: 2"

PREVIOUS VIEW REPORT

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Section Summary

Renewal Design | Best Practices | Guide Specs

Guide Specification

The guide specifications developed by the SHRP2 R23 team are contained in this document. They are organized into three sections which are: (1) guide specifications for pavement components that are not contained within the AASHTO Guide Specifications, (2) elements that can be added to or otherwise modify existing AASHTO Guide Specifications, and (3) summaries for relevant State DOT and AASHTO specifications that were used to produce the "elements" in item 2.

PREVIOUS VIEW REPORT

Tie Best Practices and Specifications Together

Tack coat between HMA lifts	It is essential that bonding between the new HMA layers courses and lower layers (such as the existing pavement) be achieved to achieve long-life performance of a long-life pavement. If this is not done, then excessive tensile strains occur resulting in fatigue cracking. This is critical for the wearing course.	• Apply the bond coat to each layer of HMA and to the vertical edge of the adjacent pavement before placing subsequent layers. • Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints. • Apply undiluted tack at a rate ranging from 0.05 to 0.10 gal/SY. • Consider the use of a hot tack (traditional paving grade asphalt cement)—reduces wheel tracking and provides a consistent tack coat which is less susceptible to run-off during a rain event. **[Refer to Elements for AASHTO Specification 404 for more details]**

Tie Best Practices and Specifications Together

Longitudinal and transverse joints	There are two major issues: (1) achieve proper joint density, and (2) stagger the joints. If the joint density is low then high air voids are the result—a typical restriction is no more that 2% higher voids in the joint than the middle of the HMA mat. If this type of criterion is violated, this leads to early joint raveling and cracking. Staggering the joints helps to prevent a direct path for water entering the pavement structure.	• Stagger joints according to AASHTO Guide Specification 401. An exception to the use of staggered joints can be made for achieving crown lines. • The minimum density of all traveled way pavement within 6 inches of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density when unconfined. **[Refer to Elements for AASHTO Specification 401 for more details]**

Infrastructure Costs and Lives

Critical Infrastructure Decisions

- Funding—do you have enough?
  - New construction (capital projects)
  - Preservation funding
  - Maintenance funding
- How long must it last?

Recent Infrastructure Costs in Washington State

Type of Infrastructure	Cost
Sound Transit Light Rail	~ $500,000,000/mi
Tacoma Narrows Bridge	~ $500,000,000/mi
Evergreen Point Bridge	~ $500,000,000/mi
Sea-Tac Third Runway	~ $500,000,000/mi

HMA overlay	$250,000/lane-mi
Seal coat	$25,000/lane-mi
Remove and replace Interstate PCC in Seattle	$2,500,000/lane-mi


Pavement Preservation and Lives

Pavement Preservation and Lives

Treatment	Cost ($/SY)	Expected Treatment Life
Slurry Seal	0.75 to 1.00	3 to 5 yr
Microsurfacing (single)	1.50 to 3.00	3 to 6 yr
Chip Seal (single) Conventional	1.50 to 2.00	3 to 7 yr
Chip Seal (single) Polymer Modified	2.00 to 4.00	5 to 10 yr
Thin HMA Overlay (0.875 to 1.5”)	3.00 to 6.00	5 to 12 yr
Ultra-Thin HMA Overlay (0.625 to 0.75”)	2.00 to 3.00	4 to 8 yr
Ultra-Thin Whitetopping (2 to 4”)	15.00 to 25.00	NA

Source: SHRP2 R26


5 SOUTH
Tacoma
Portland
EXIT 164
TO 90 EAST
Bellevue
Spokane
Dearborn St.
4th Ave S.
Airport Way

State DOT Budget Ranges

Budget Element	Total
Operating (take care of what you own)	24 to 27%
Pavement Preservation (contracts only)	(6 to 10%)
Bridge/Structures Preservation	(4 to 6%)
Highway Maintenance	(6 to 8%)
Capital Projects (new stuff)	73 to 76%
Total Budget	100%

WSDOT Lane-kilometers

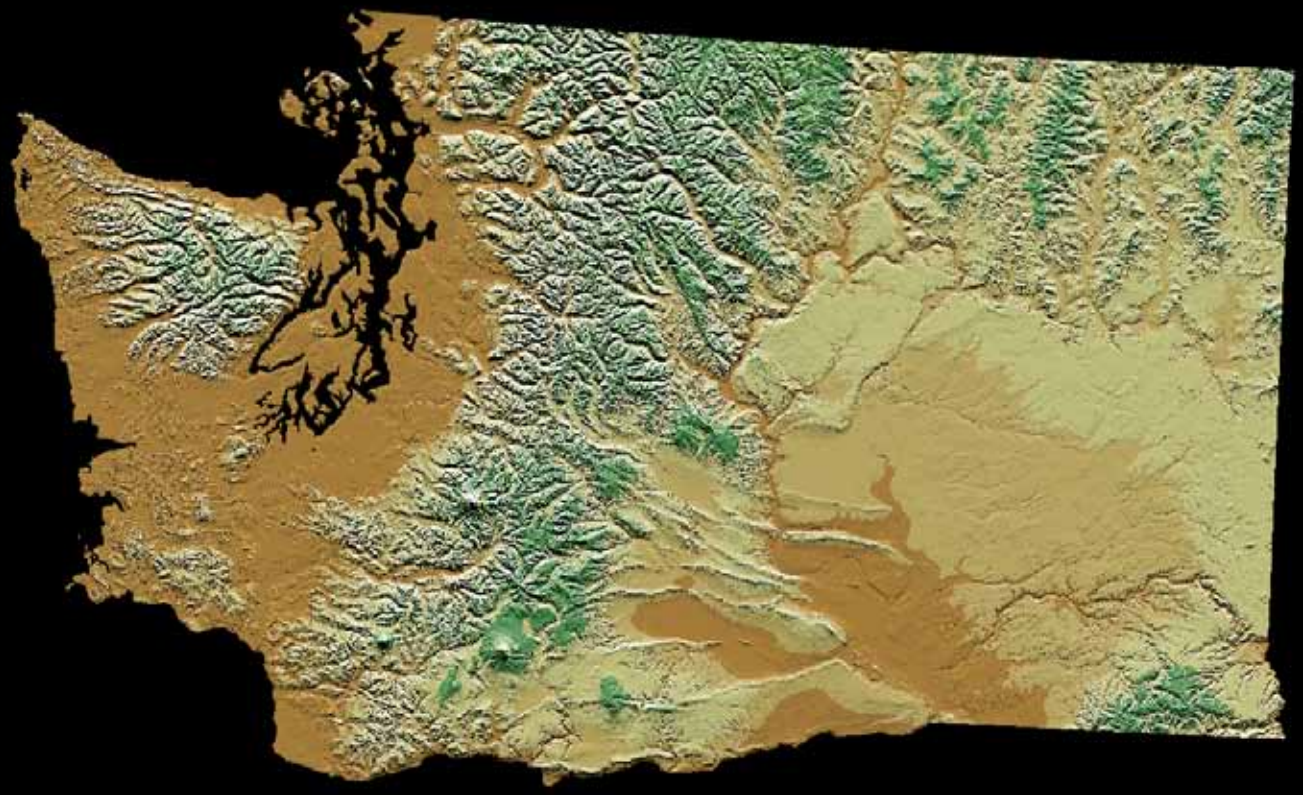
Pavement Type	Lane-miles	% of Total
HMA	10,800	60
BST	4,800	27
PCC	2,300	13
Totals	17,900	100

WSDOT Pavement Preservation Funding

Budget Element	Total
1. Typically spends per year	$7,000/ln-mi/year
a. HMA portion of system	$8,700/ln-mi/year
b. BST portion of system	$2,700/ln-mi/year
c. PCCP portion of system	$4,300/ln-mi/year
2. Should spend per year	> $10,000/ln-mi/year

How much does your agency spend on pavement preservation?

A quick view on pavement performance as measured by the Interstate highways in Washington State



How Long with it last?

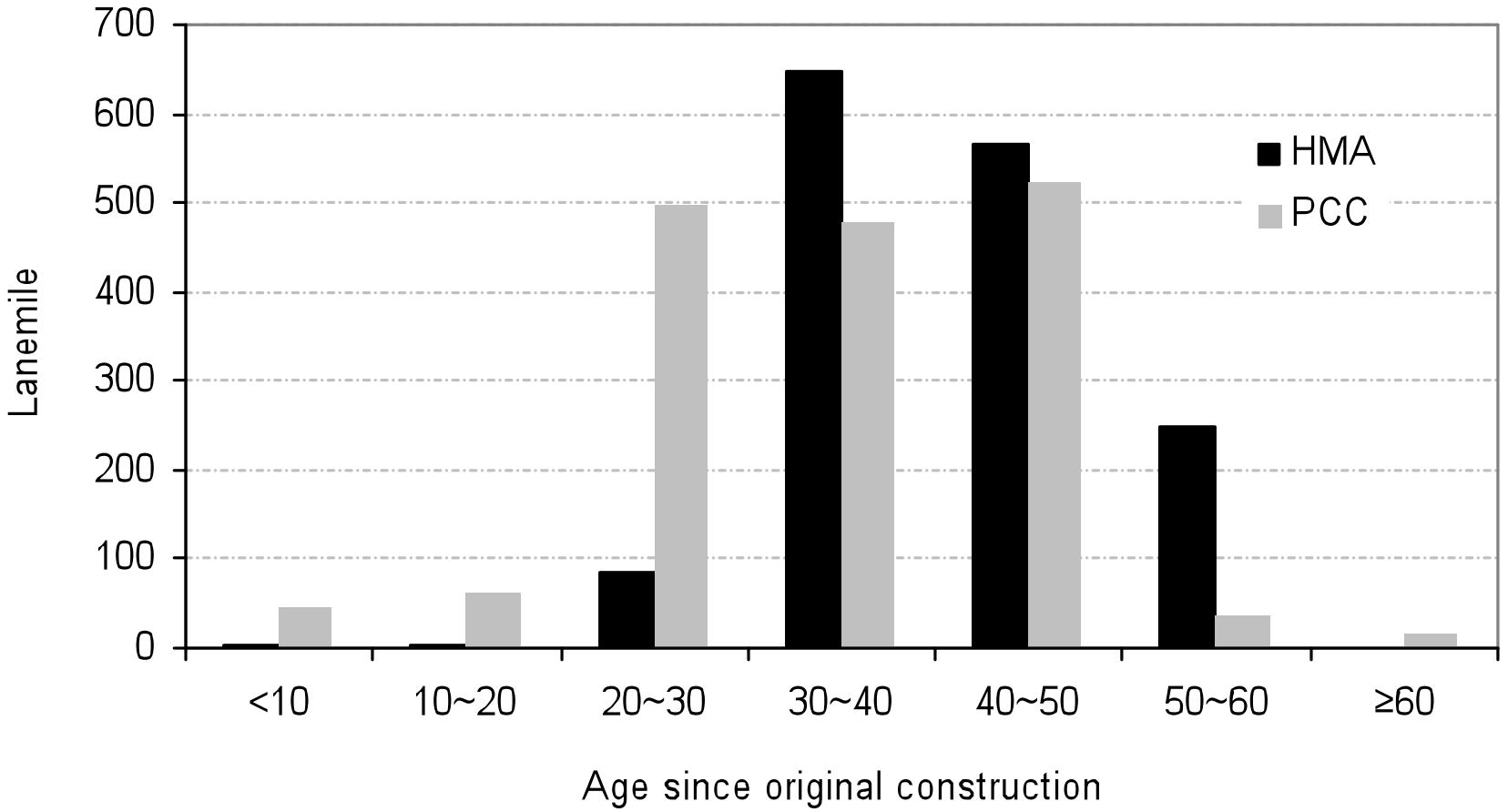
Project	Life
Expected life of new bridge	> 150 years
New pavements	≥ 50 years
HMA overlay	~ 15 years
Seal coat	~ 7 to 10 years

Can we do better?

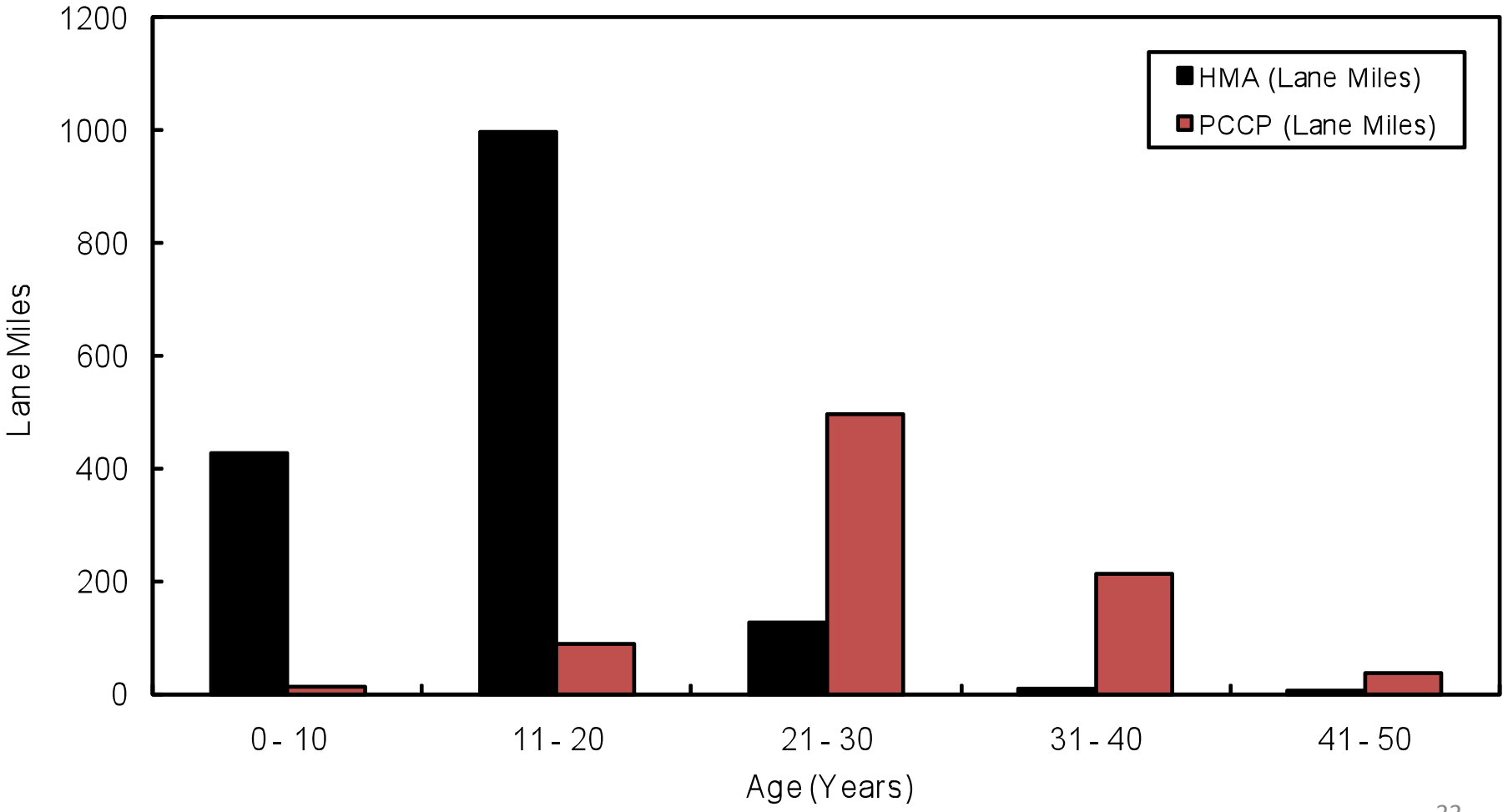
How do we do better?

A quick view to how we are doing…

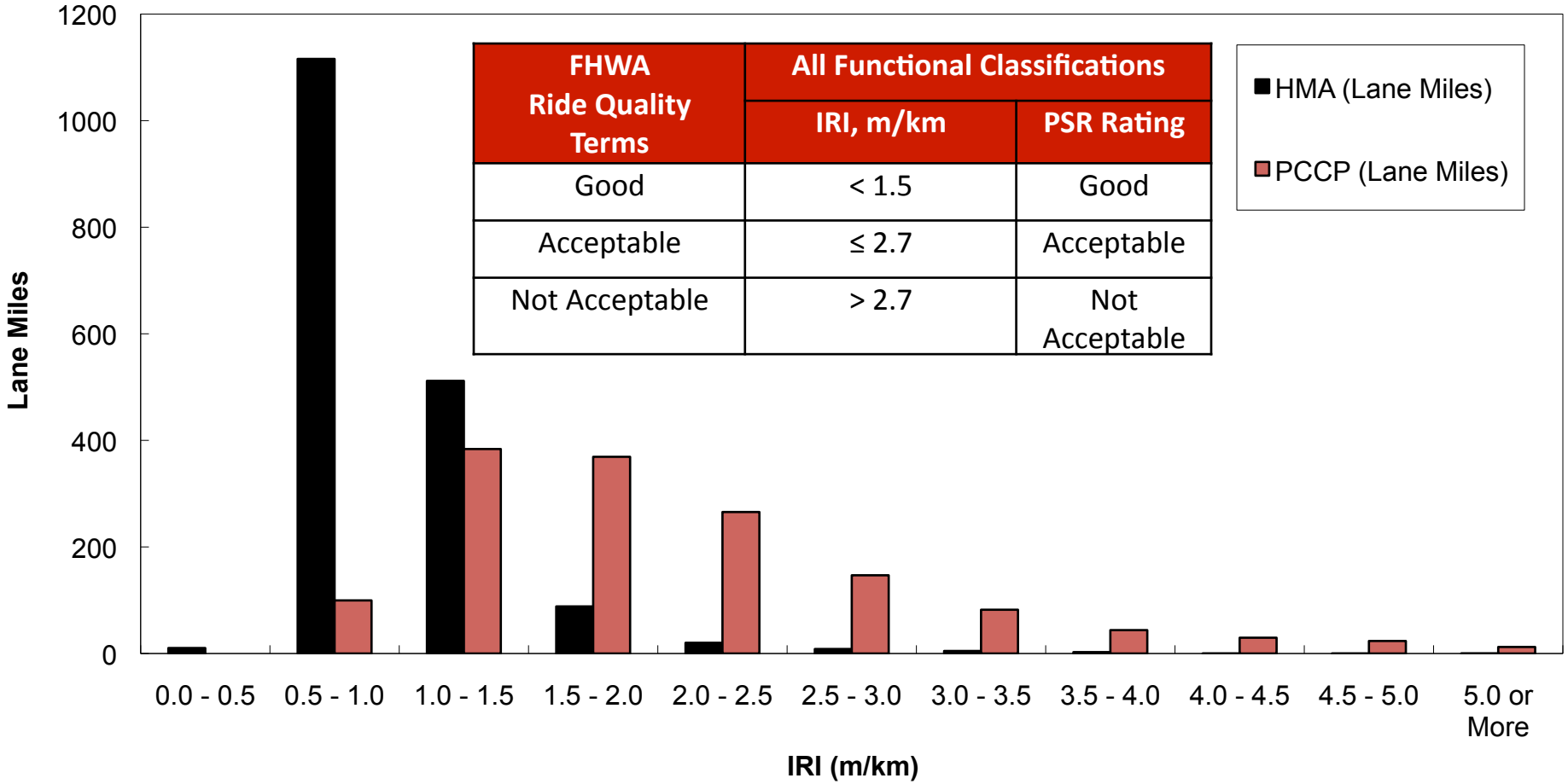
Interstate Pavement Ages



Interstate Pavements
Time to First Rehabilitation



Interstate Pavements International Roughness Index



FHWA Ride Quality Terms	All Functional Classifications	
	IRI, m/km	PSR Rating
Good	< 1.5	Good
Acceptable	≤ 2.7	Acceptable
Not Acceptable	> 2.7	Not Acceptable

Transportation Research and Development

Research and Development Spending as a function of Sales

Industry (1000 Global Companies)	Percent of Sales
Software and Internet	12.7
Health	11.2
Computing and Electronics	7.6
Technology	4.3
Aerospace and Defense	4.1
Auto	4.1
Industrials	2.3
Telecom	1.9
Chemicals and Energy	1.5

Average = 4.2%

Source: Booz Allen Hamilton Global Innovation 1000

Research and Development Spending as a function of Total Revenue

Company	Percent of Revenue
Motorola	10%
3M	7%
Boeing	5%
IBM	5%
Honda	5%
Ford	4%
Toyota	4%
Caterpillar	2%

Sources: (1) Wall Street Journal, and (2) Booz Allen Hamilton Global Innovation 1000.

Research and Development Spending as a function of Revenue

Company	Percent of Revenue
Software companies	
Microsoft	21%
Oracle Corp	12%
Drug companies	
Pifzer	15%
AstraZeneca	16%

Sources: (1) Wall Street Journal, and (2) Booz Allen Hamilton Global Innovation 1000.

Research and Development Spending as a function of Total Revenue

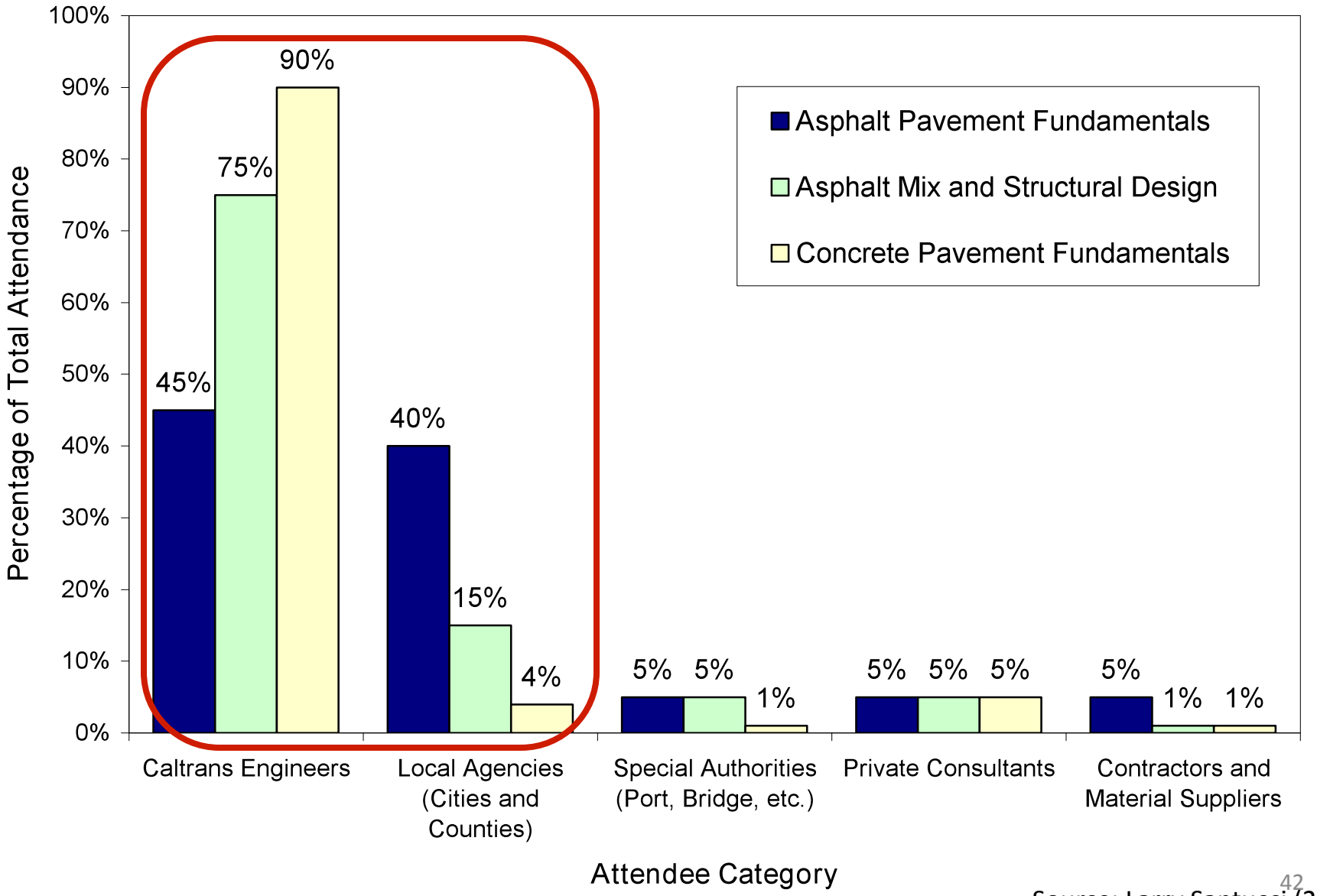
Agency	Percent of Revenue
Federal Highway Administration	~ 0.5%
State DOTs	Varies but most of funds from federal sources ~ 0.1 to 0.2%

Sources: (1) TRB Special Report 261, "The Federal Role in Highway Research and Development," and (2) TRB (http://www.trb.org/ResearchFunding/StateDepartmentofTransportation.aspx).

Notes: (1) Typical State DOT research contracts range from $100,000 to $300,000, (2) Federal government, on average, provides State DOTs with $3,000,000/year for research and development, (3) Bridge research for State DOTs about 5 to 30% of state research budgets (based on a survey of 25 State DOTs during 2008).

Pavement-Related Training

California Course Participants



Source: Larry Santucci (2002)

On Demand Costs

Item	Cost per minute of use
Avatar—3D Movie	$0.10
Professional baseball game ($40 tickets)	$0.22
Live opera (NY Met)	$0.37
Rolling Stones Concert ($100 tickets)	$0.83

On Demand Cost

Item	
Two day short course ($ course)	
Two day short co attendee sala	42
Traditional	3 to 0.15/minute
Online	$0.05 to 0.10/minute

- Traditional training is expensive and is challenged to target a broader audience.
- Online Learning Resources?

1. Assumes $65/hou
2. Ignores value of stud

pavement interactive

Log in / create account

article | discussion | view source | history

search

Go Search

navigation

- Main Page
- Reference Matls
- Recent changes
- Available Feeds
- Random page
- Sources
- Glossary
- Help

Welcome to Pavement Interactive!

(Redirected from Main Page)

Search

The online community for all things pavement containing over 523 articles and 3,584 files.

articles
an encyclopedia of pavement knowledge

maps
browse and store data on a map

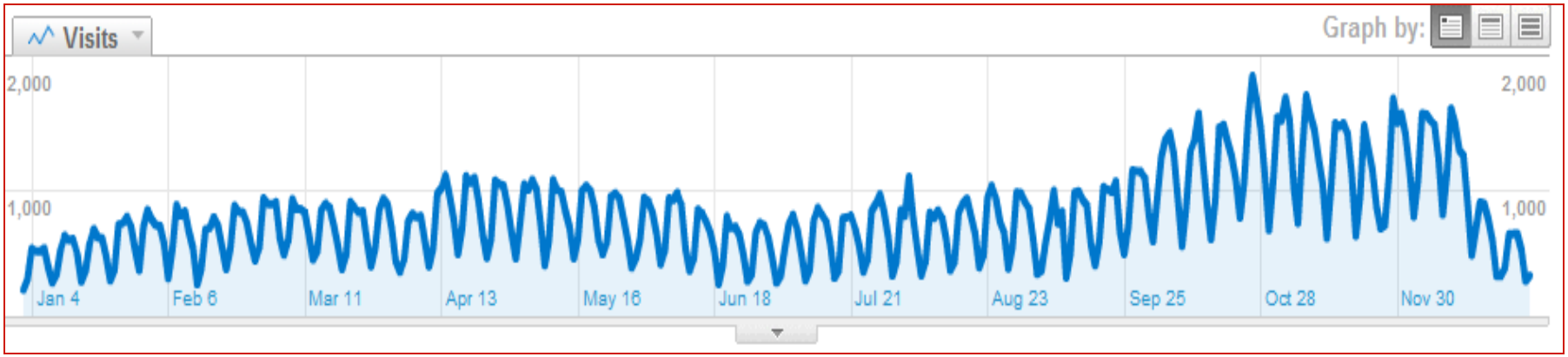
groups
work and collaborate with others online

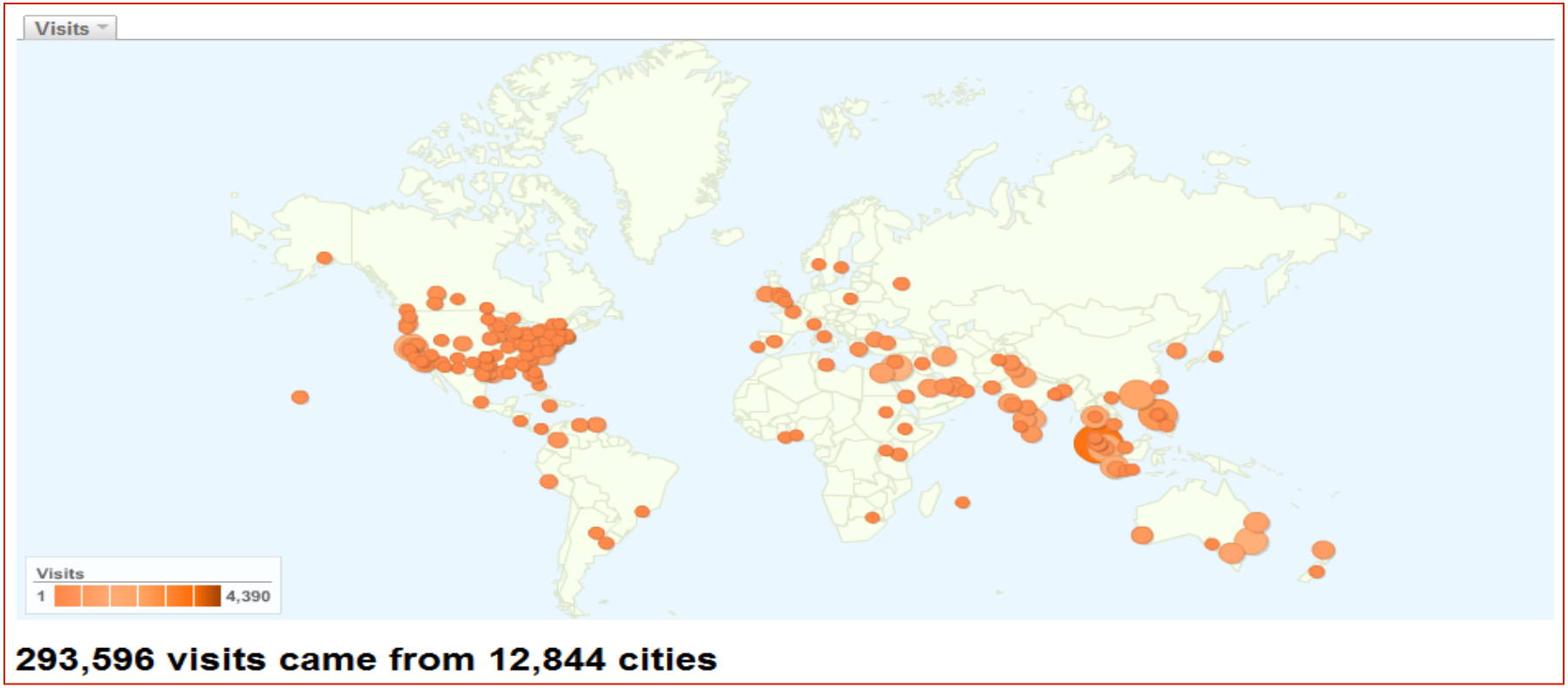
help
where to get started and the how to

sponsor portals

Pavement Interactive

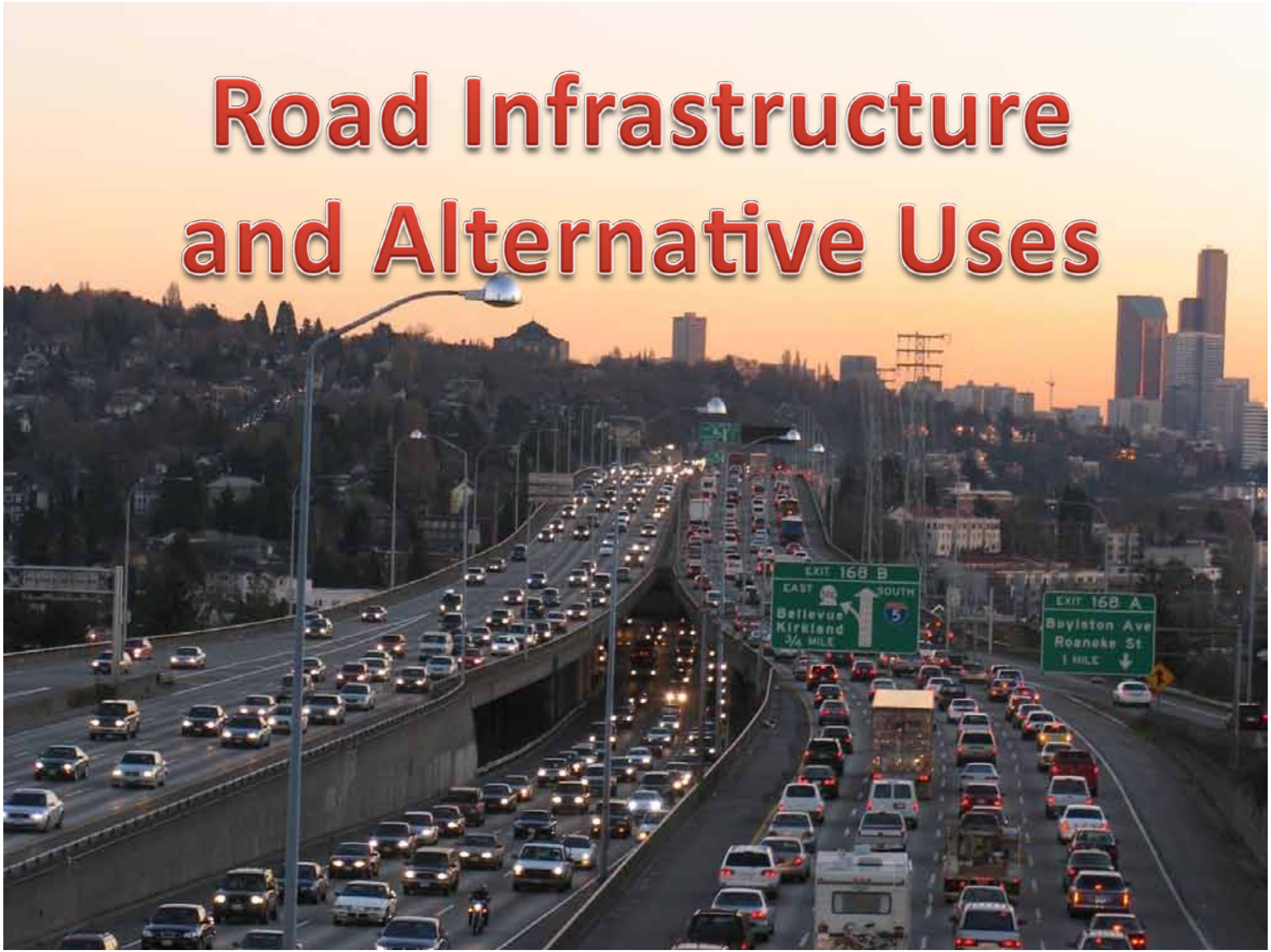
PI Use Stats from Jan 2 10 to Jan 1 11





293,596 visits came from 12,844 cities

Road Infrastructure and Alternative Uses



Roads—there are a bunch

World Rank	Country	Paved Roads (mi)	Road miles per 1000 population
1	USA	2.5 million	8.7
2	India	1.0 million	0.9
3	China	1.0 million	0.7
4	France	0.6 million	9.4
5	Japan	0.5 million	4.4
	World Total	10.8 million	1.7

Sources: CIA Fact Book and NationMaster.

Roads by ownership in the US

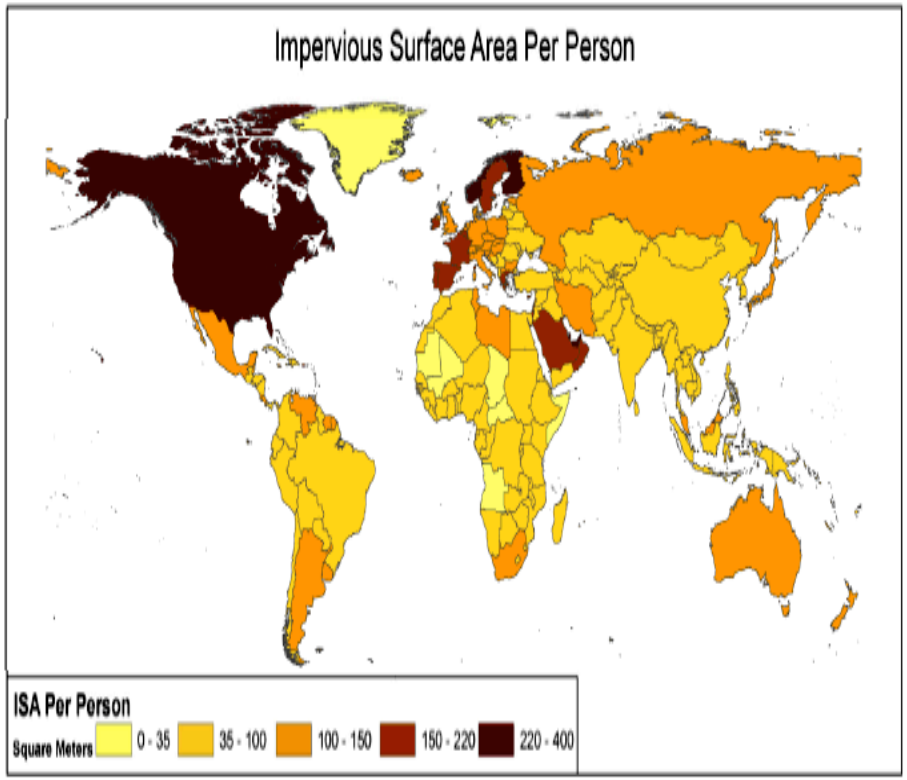
Owner	Miles	%
State	759,000	20%
County	1,733,000	44%
City /Town/Muni	1,233,000	31%
Federal	124,000	3%
Other	64,000	2%
Totals	3,903,000	100%


Johannesburg


Sao Paulo


Dallas

Impervious Surfaces



- World impervious surfaces ≈ 143 million acres or about 0.4% of total land area.
- US impervious surfaces ≈ 21 million acres or about 1.0% of total US land area.
- Hard surfaced pavements ≈ ½ of impervious surfaces (or 72 million acres) worldwide.

Source: Elvidge, Tuttle, et al "Global Distribution and Density of Constructed Impervious Surfaces," Sensors, 2007.

Impervious Land Areas

Country	Imperious Surface Area (km^2)	Total Land Surface Area (km^2)	% ISA
China	87,000	9,600,000	0.9
US	84,000	9,800,000	0.9
India	81,000	3,200,000	2.5
Brazil	18,000	8,500,000	0.2
World	580,000	150,000,000	0.4

1. ISA = Imperious surface area which is composed of roads, parking lots, sidewalks, buildings, and other human-built surfaces.
2. About ½ of ISA covered by pavements.
3. About 150 m^2 pavement/person in the US.

Lots of Energy Used Worldwide

Total Energy Used for Selected Countries

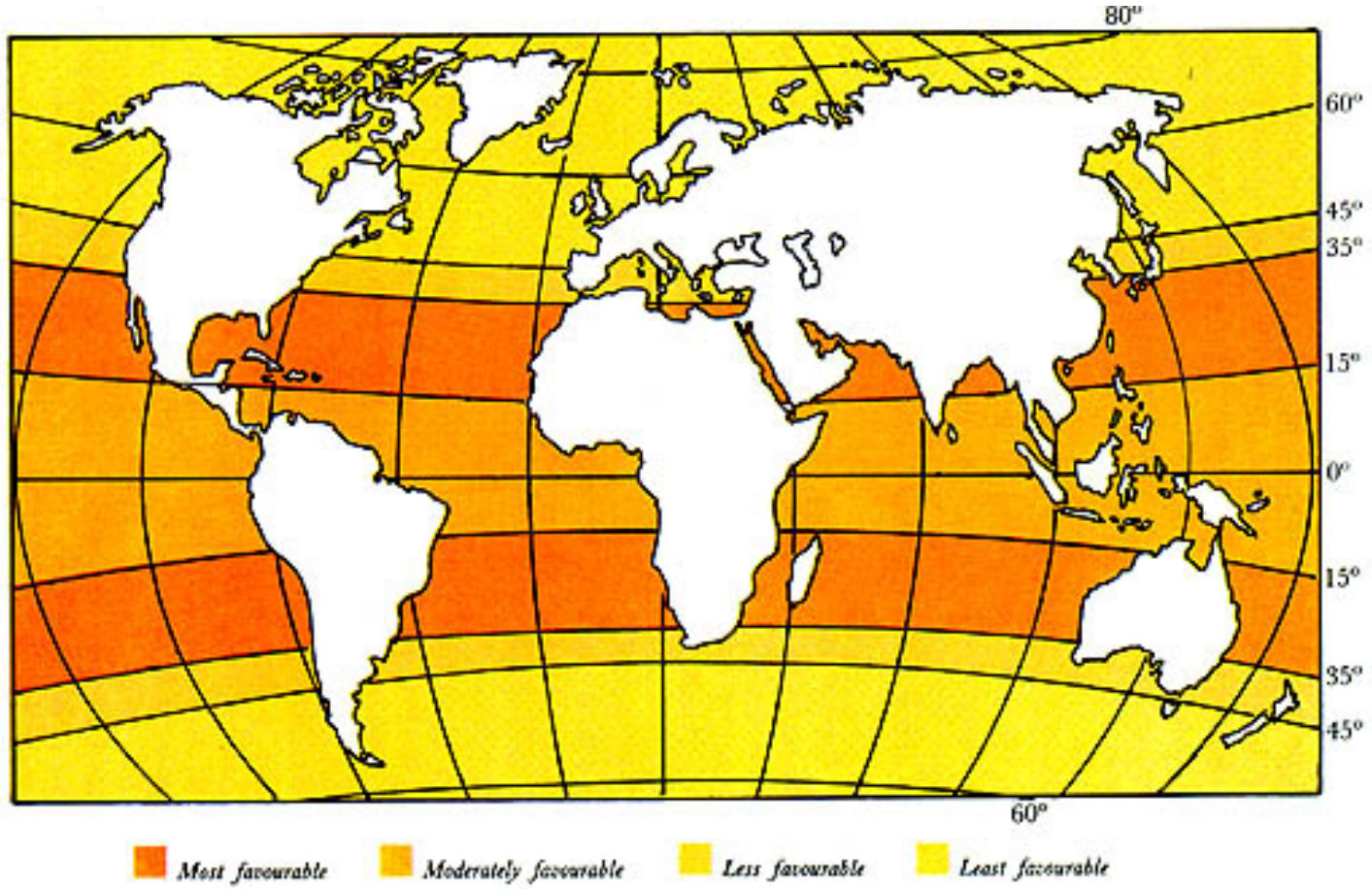
Country	ay
Costa Rica	
China	40
Europe	125
USA	250
Canada	270
UAE	360
Iceland	380

Most of world population ≤ 75 kWh/person/day

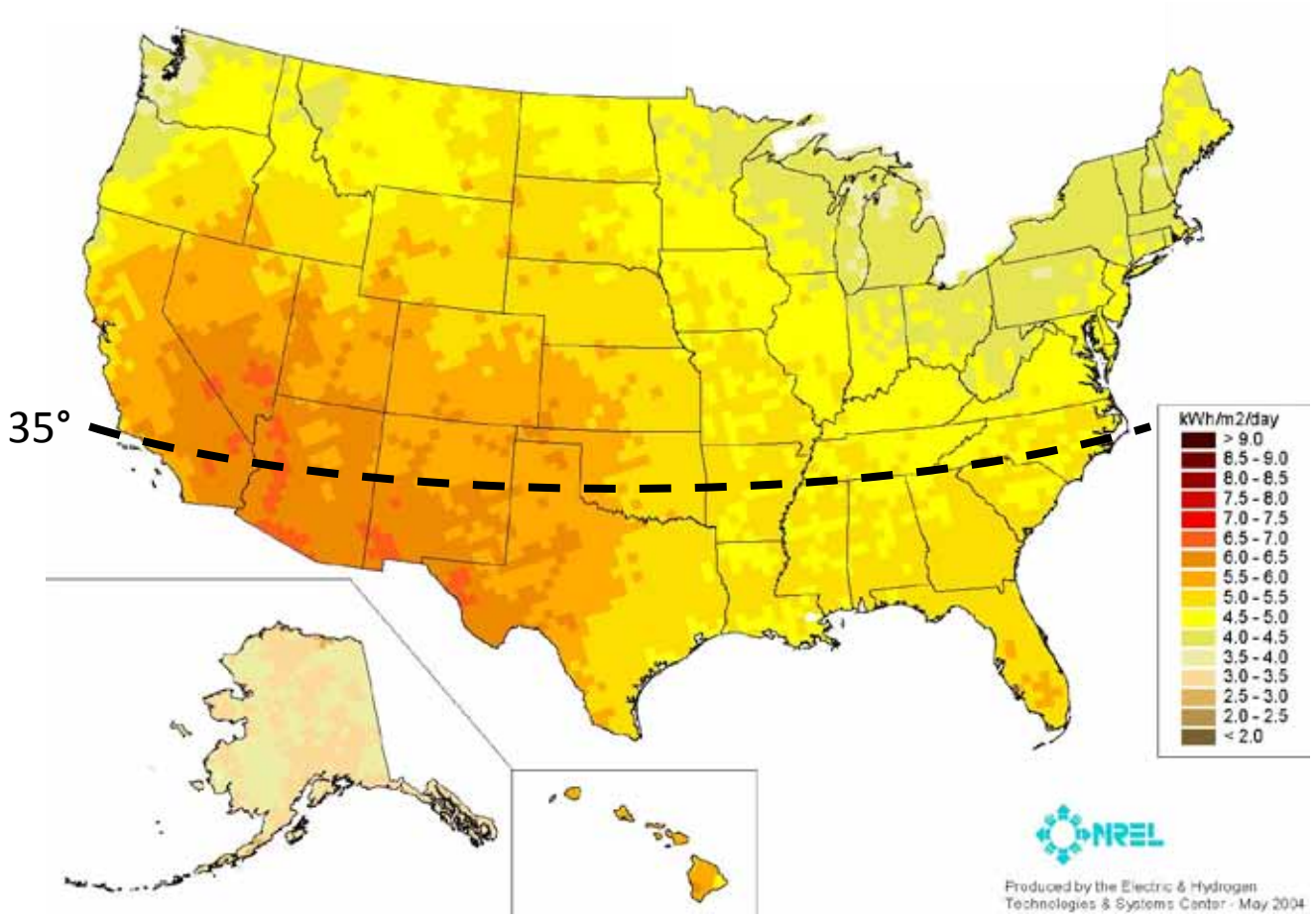
Note: Includes tr (auto, flights), food, heating/cooling, lighting, other stuff.

Source: David McKa "Sustainable Energy—Without the Hot Air."

Best regions for solar is 15° to 35° latitude



Annual Solar Radiation (kWh/m^2/day)



150 m^2/person x 5 kWh/m$^{2/}$day x 0.1 conversion efficiency = 75 kWh/person/day

How to make photovoltaic coatings become much cheaper…and turn roads into electrical utilities?

Substantial R&D

How do we encourage such developments?

- Maybe we start like the Oregon DOT did.
- Feed-in tariffs will likely be part of the mix.

Concluding Thoughts

Concluding thoughts

- Are we spending enough on pavement preservation?
- Are we spending enough on research and development?
- Do we have the “right” mix of training and training resources?
- Are we doing a proper mix of research?

Gasoline Prices—2011

Country	Gasoline Total Costs ($/gal)
Saudi Arabia	0.61
Venezuela	0.87
USA	3.00
Japan	5.19
UK	7.50
France	6.89
Denmark	7.84
Greece	7.91
Norway	8.74

Sources: Various sources including Wikipedia.

The End


EXIT 168 B
EAST
SOUTH
Bellevue
Kirkland
¾ MILE
EXIT 168 A
Boylston Ave
Roanoke St
1 MILE