Hot-Mix Asphalt (HMA)

Balancing Risk & Assuring Performance

North-East State Materials Engineers Association
Atlantic City, New Jersey
October 8th 2008

Thomas Harman

Team Leader – Senior Pavement Engineer

Federal Highway Administration - Resource Center

Pavement & Materials TST

U.S. Department of Transportation
Federal Highway Administration

MOVING THE AMERICAN ECONOMY

CHANGE

The dogmas of the quiet past are inadequate to the stormy present… as our case is new, so we must think anew and act anew.

Our Visit

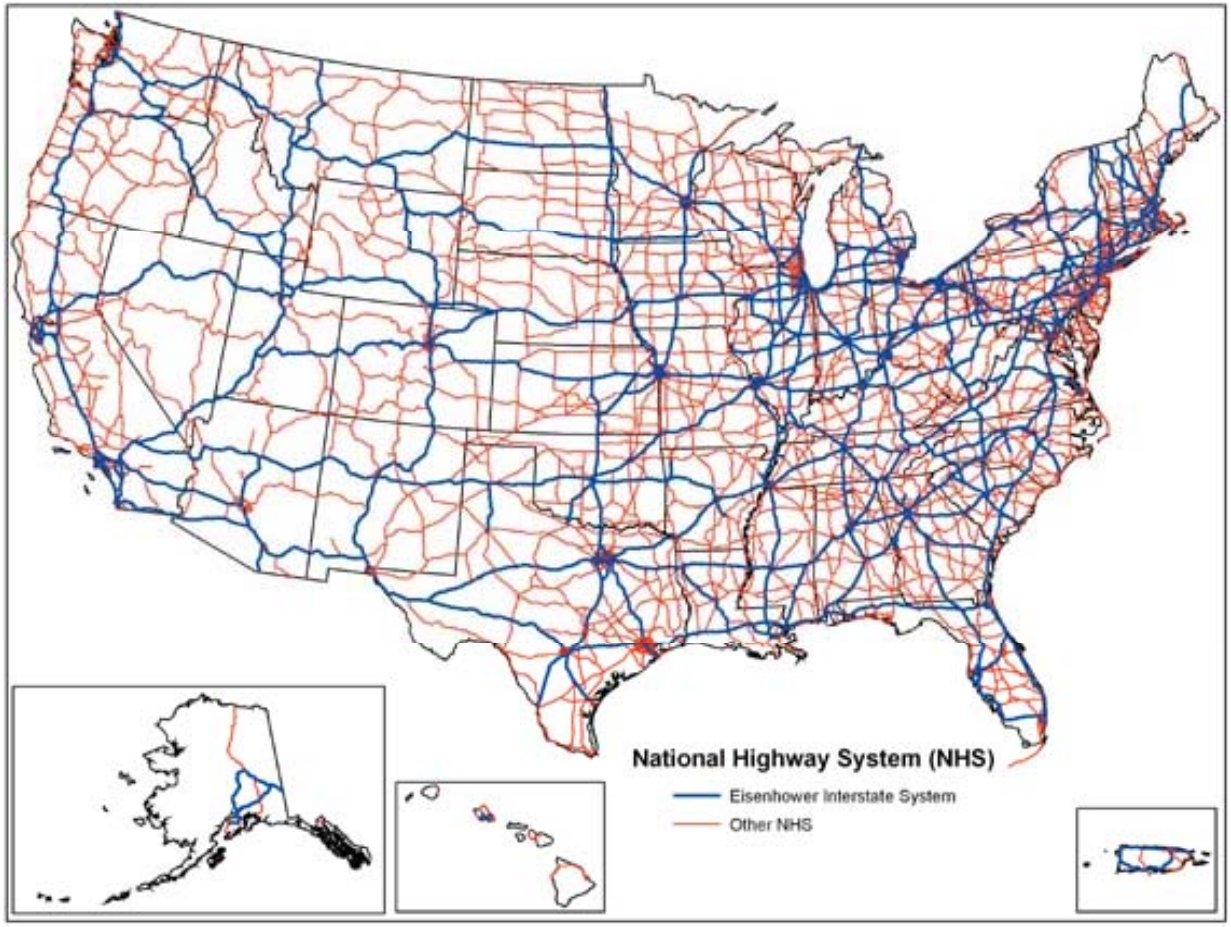
- Our Nation's Transportation System
- ***Balancing Risk & Assuring Performance***
  - Need
  - Structural Design & Analysis
    - Pavement Type Selection, RealCost™
  - Materials Characterization & Design
    - Superpave PGx, AMPT, Mix Type Selection Guide, NAPA/FHWA
  - Quality Assurance Systems
    - 6+ Building Blocks
  - Production & Placement
    - Automation, Innovation, & Basics
  - Monitoring & Preservation
    - Thinking about tomorrow to drive today's decisions
- GOAL: Provide you with resources!

Need | Structure | Materials | Acceptance | Construction | Preservation

Two Words About
Our Nation's Transportation System

National Statistics:

3,963,262 miles of Roads 590,000 Bridges
2.7 trillion vehicle-miles / year

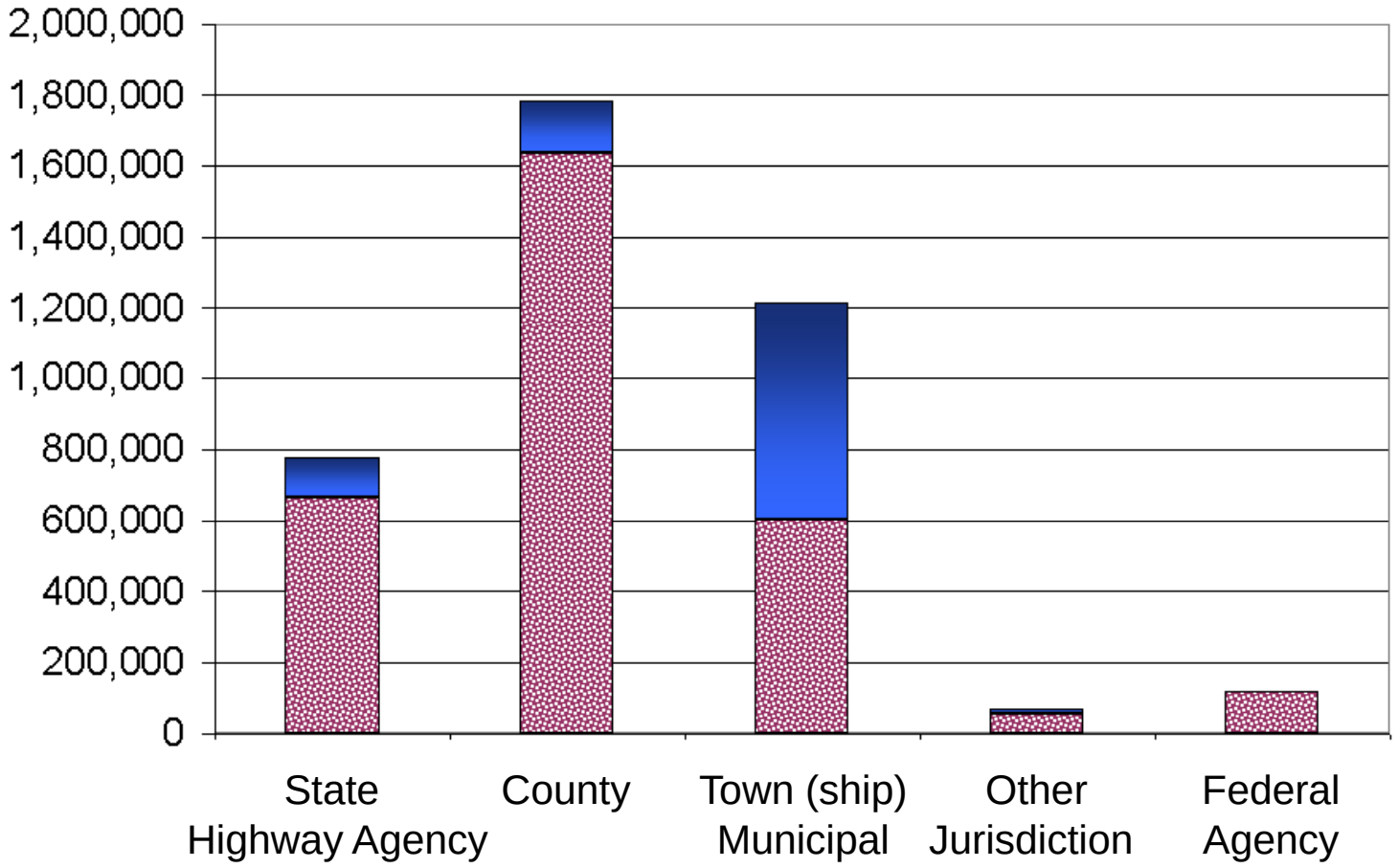


National Statistics:

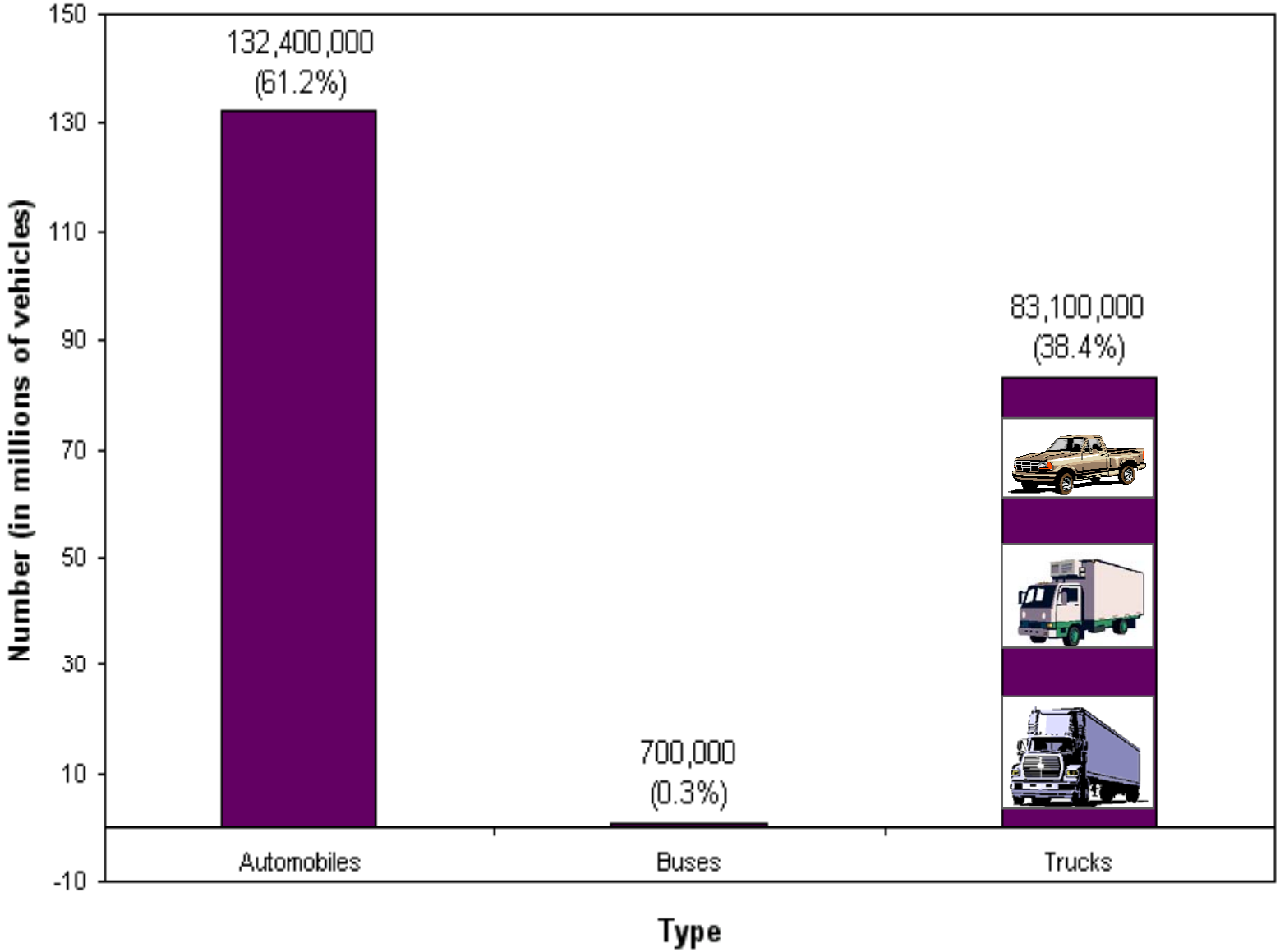
3,963,262 miles of Roads

U.S. Public Road Ownership (Centerline Miles)

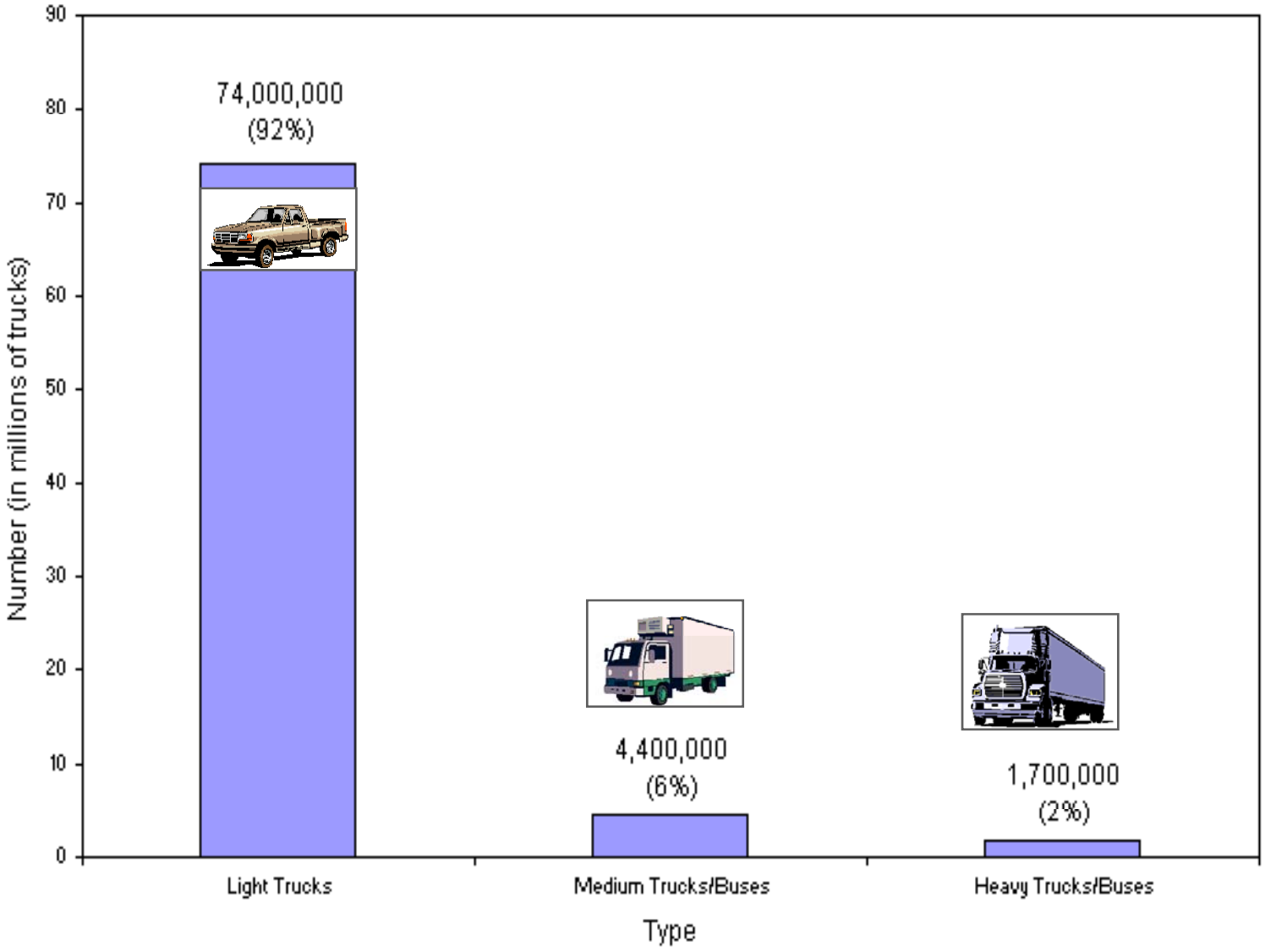
Urban (Solid) vs. Rural (crosshatched)



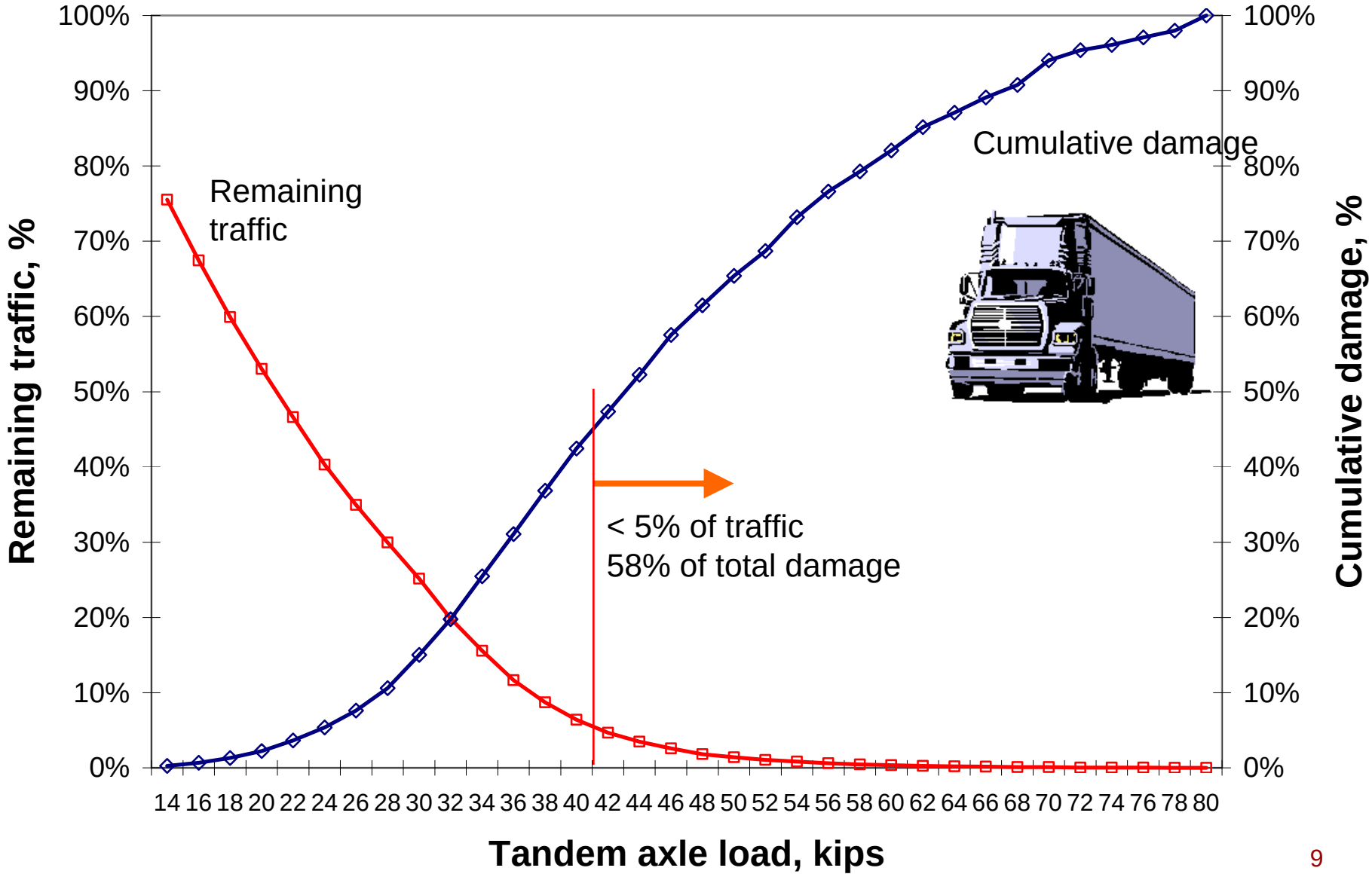
US Vehicle Population in 2000



Truck Distribution

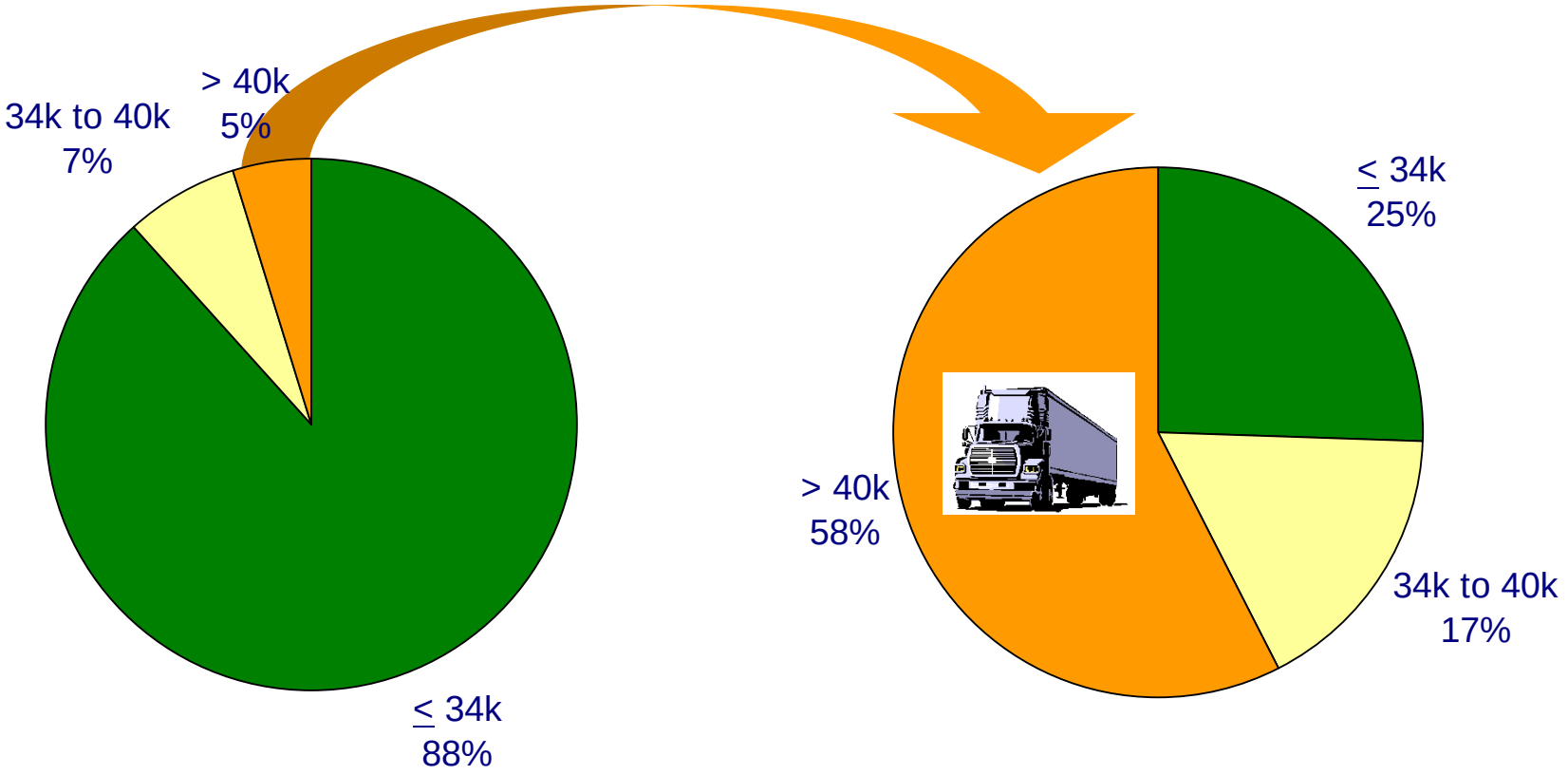


Damage vs. Axle Weight



Damage vs. Axle Weight

5% of traffic causes almost 60% of damage



Traffic distribution

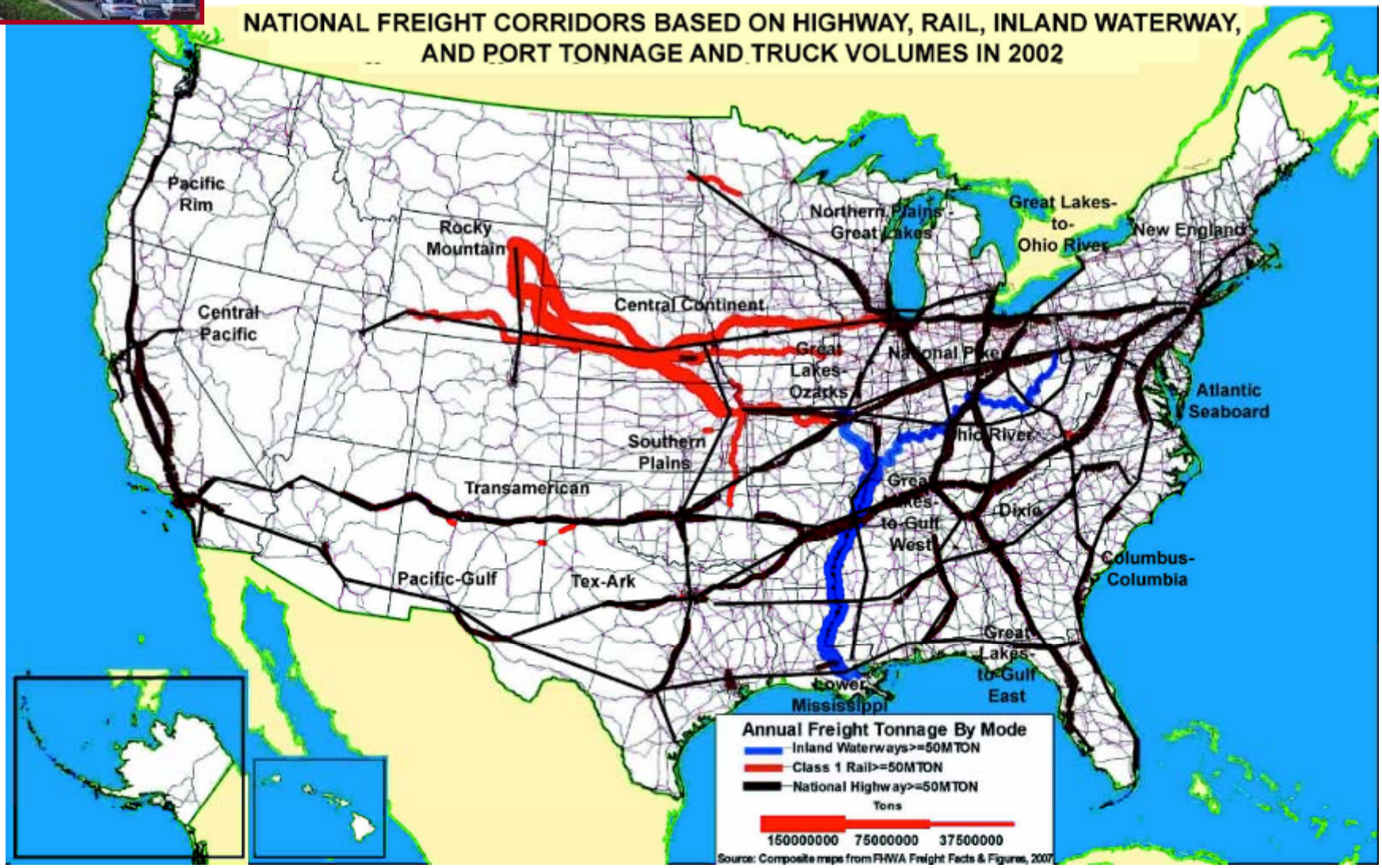
Damage distribution

Networks… Intermodal

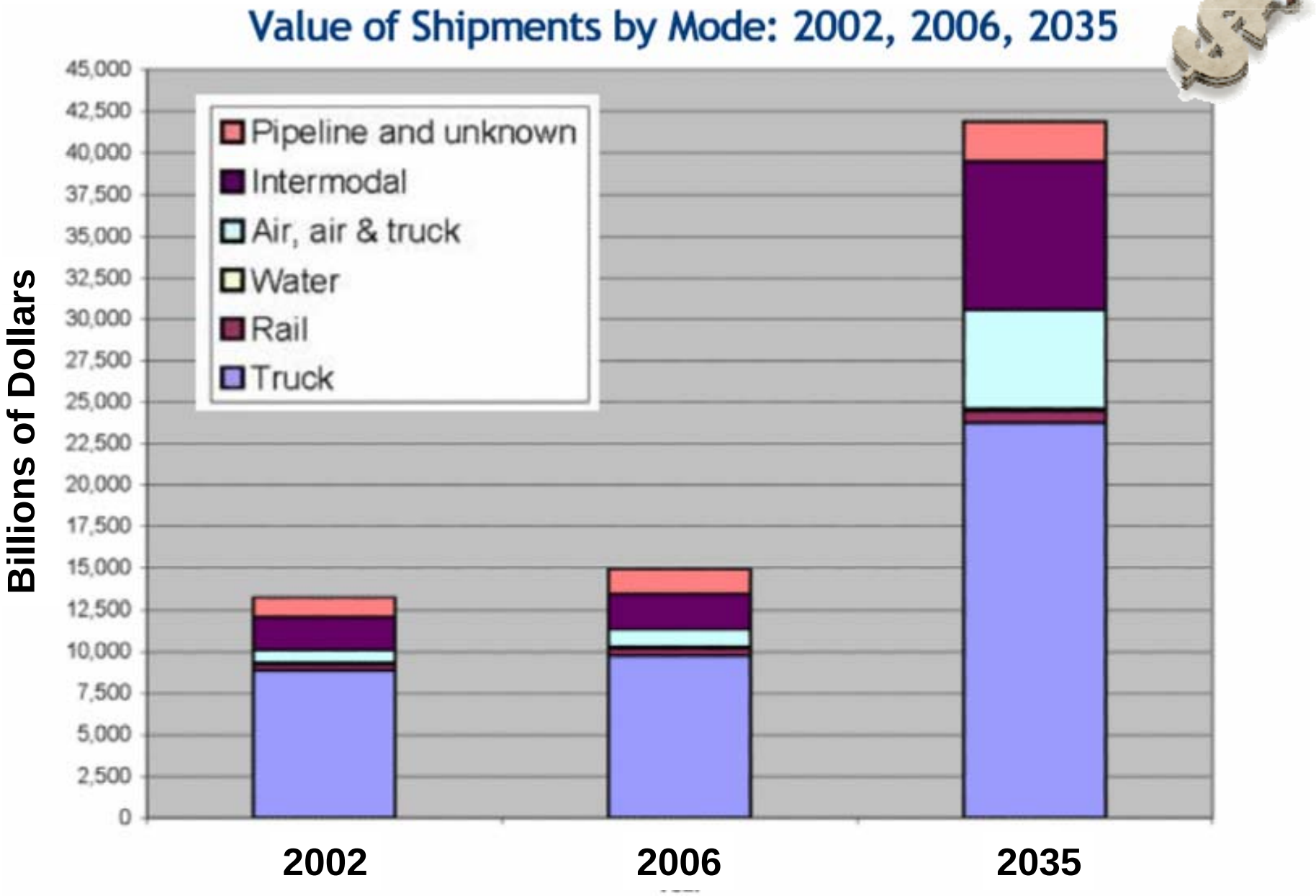
Air | Truck | Rail | Water | Pipeline

Highway Network

National Freight Corridors

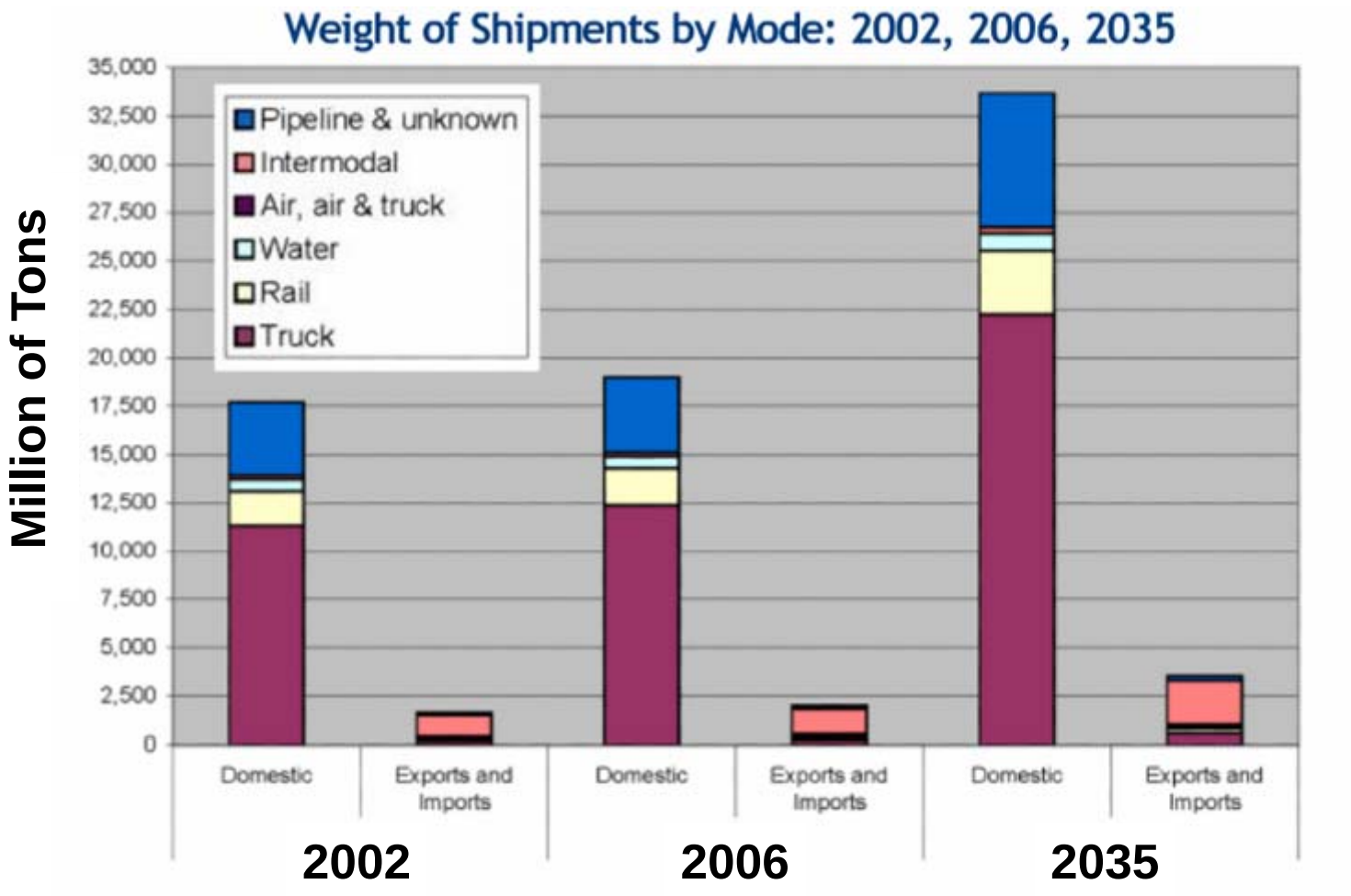


Commerce


Value of Shipments by Mode: 2002, 2006, 2035
Billions of Dollars
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
22,500
20,000
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
Pipeline and unknown
Intermodal
Air, air & truck
Water
Rail
Truck
2002
2006
2035

Tonnage

In the US, an average 53 million tons of freight was moved each day in 2002…



Why Key

- An efficient freight transportation system can also improve a State or Region's ability to attract and retain businesses

Economic Vitality and Competitiveness

The Environment

Safety and Quality-of-Life

National Security

CHANGES

- Congestion and Freight are driving factors
- Increased traffic and loadings
- Environmental Concerns (sustainability)
  - ex. Use of bag-houses at production facilities, increase in recycled materials
- Supply sources (asphalt, polymers, aggregates)
  - Escalating materials costs
- Production changes
  - ex. Drum plants vs. batch plants
- Staff reductions
- Shifting roles
- Personnel experience & shortages

Balancing Risk & Assuring Performance

- Risk
  - Risk is the likelihood of a bad or unwanted outcome – such as poor pavement performance or low profit margin (or crap dice)
  - All systems have some inherent Risk, and
  - Changes within a system will either increase, decrease, and/or shift Risk between parties,
    - ex. Owner Agency & Contractor

Balancing Risk & Assuring Performance

- Risk - Law of Unexpected Consequences…

“Sometimes in getting what you ask for you loose what you truly wanted.”

Balancing Risk & Assuring Performance

Innovation

- New materials, testing tools, and production equipment and procedures offer the potential for even greater pavement performance!

Balancing Risk & Assuring Performance

Risk and Innovation

- In developing systems that reduce overall Risk, we can create an environment that does **NOT** foster or reward innovation.

Balancing Risk & Assuring Performance

proach

Get In

Structural

Stay In

Get Out

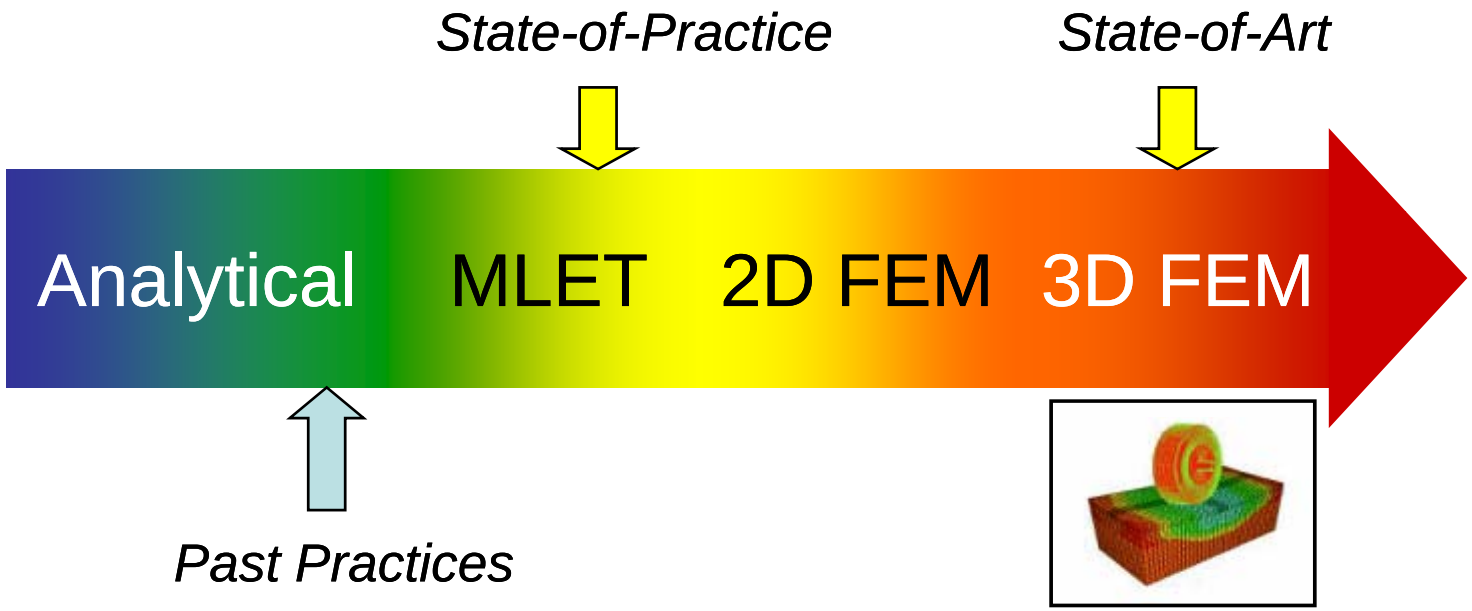
Stay Out

Materials

Construction

Need | Structure | Materials | Acceptance | Construction | Preservation

Evolution of Pavement Design



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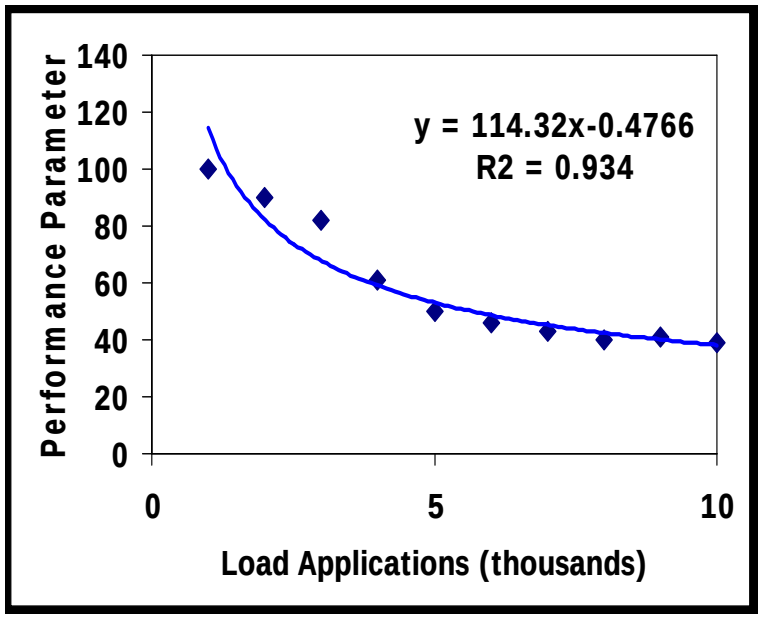
Evolution of Pavement Design

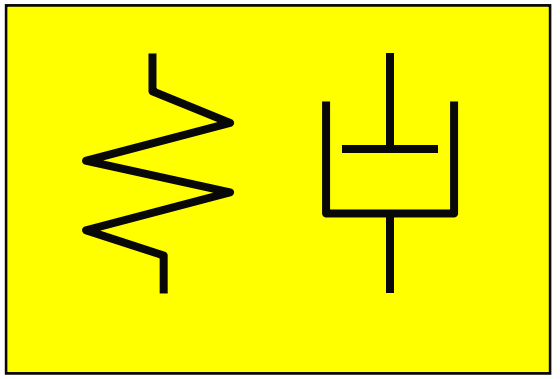
Empirical



- Get a lot of data
- Find a Trend (Hope for)

Mechanistic

- Springs
- Dashpots



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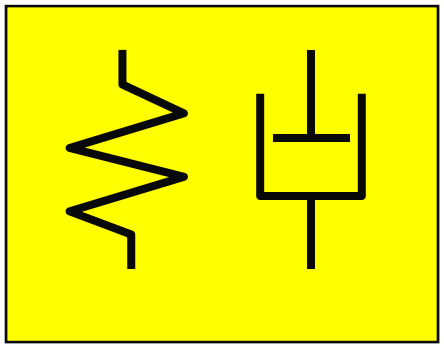
Evolution of Pavement Design

- Mechanistic-Empirical
  - Combines mechanistically based models (equations) with empirically derived models (equations)



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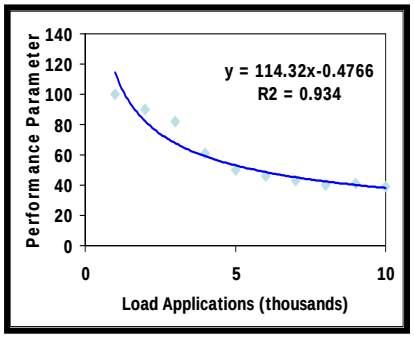

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AASHO
Interim Guide
for the Design

FOREWORD

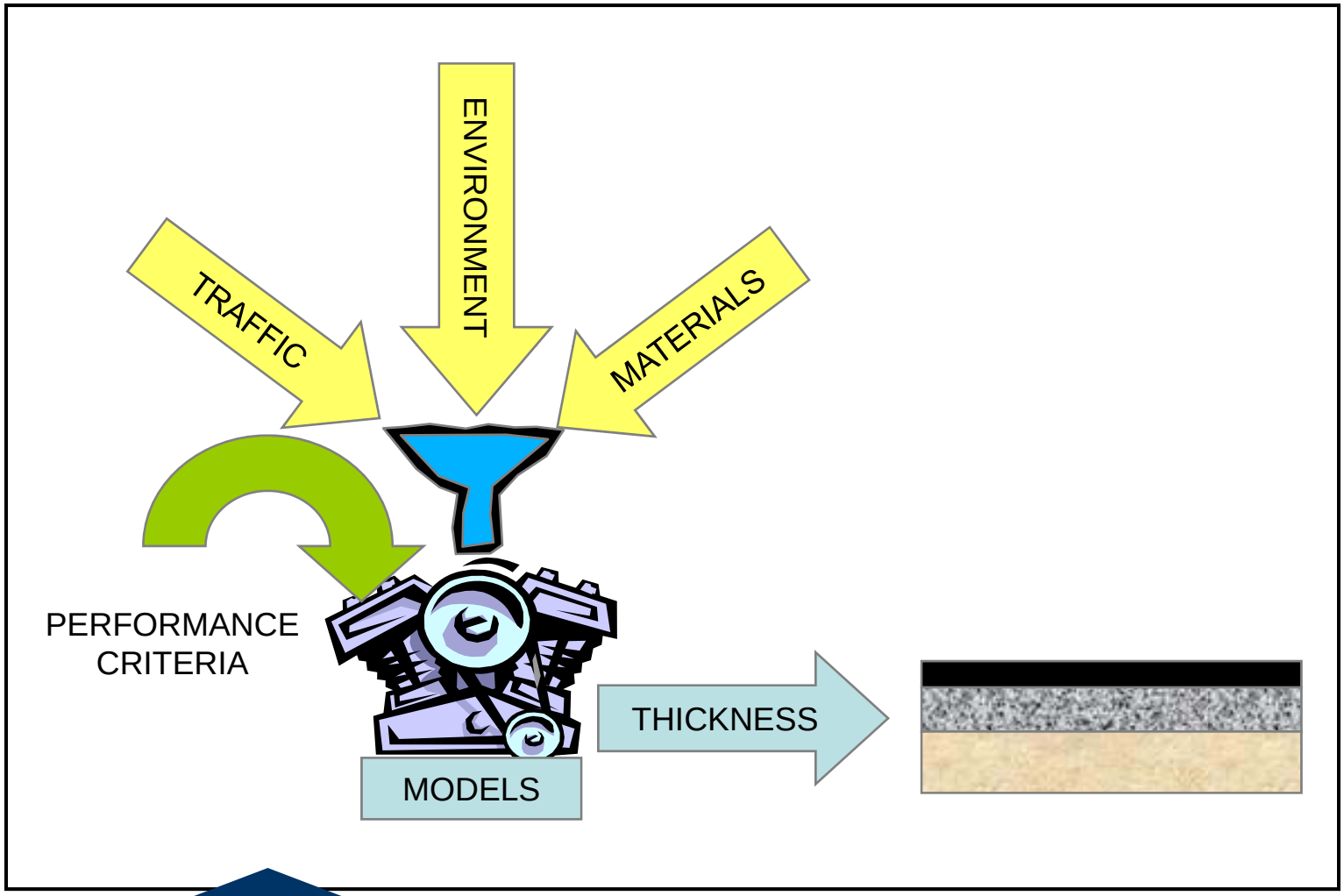
This interim guide for the design of pavement structures is based on data from the AASHO Road Test at Ottawa Illinois. In those areas not covered by the Road Test, theoretical analysis and experience have been utilized.

It is essential that the user of the guide understand its limitations, which are: …

Environmental Section is still in-place today.

Fred Finn – Bituminous Engineer for the Track

New AASHTO M-E Pavement Design Guide



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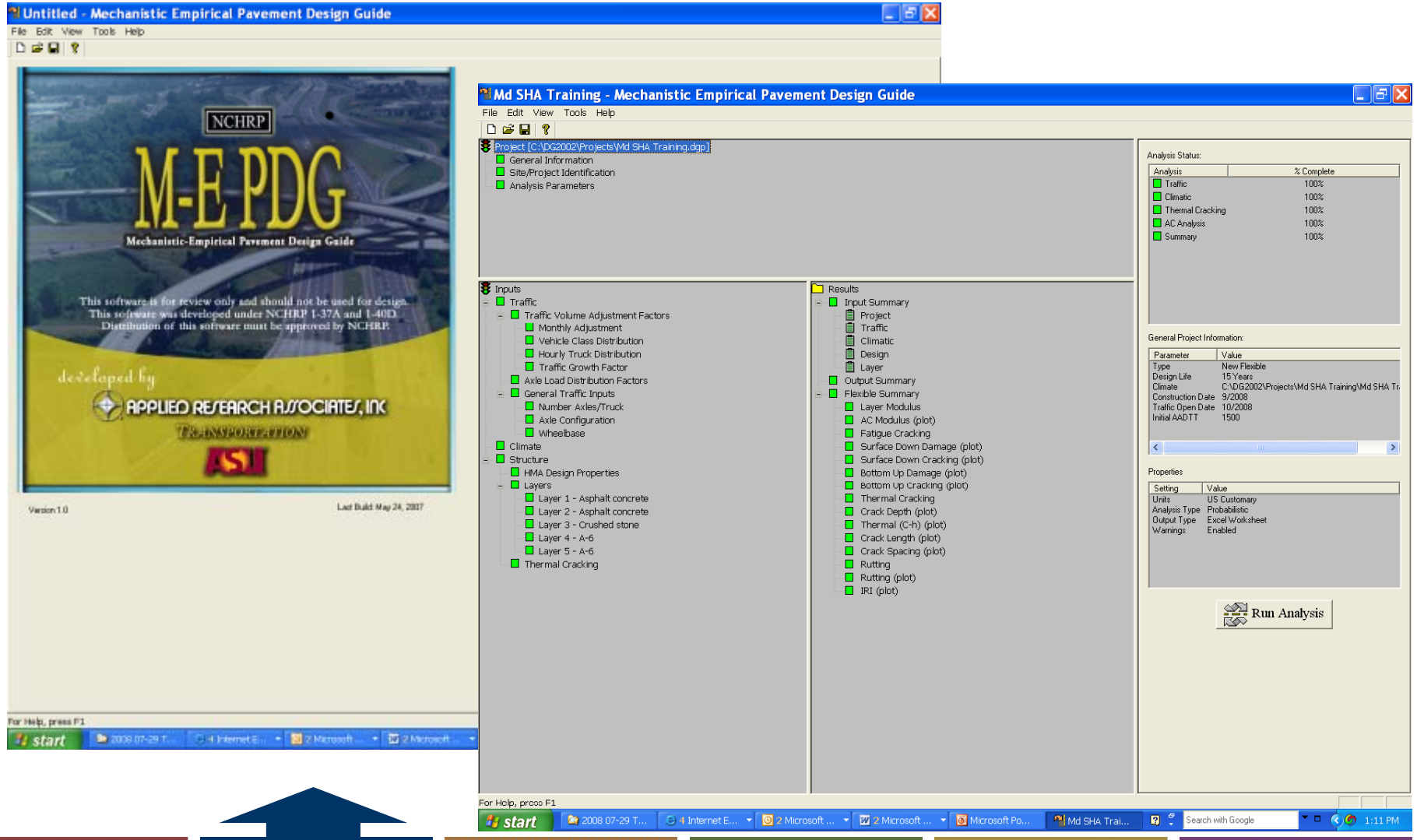
New M-E Pavement Design Guide



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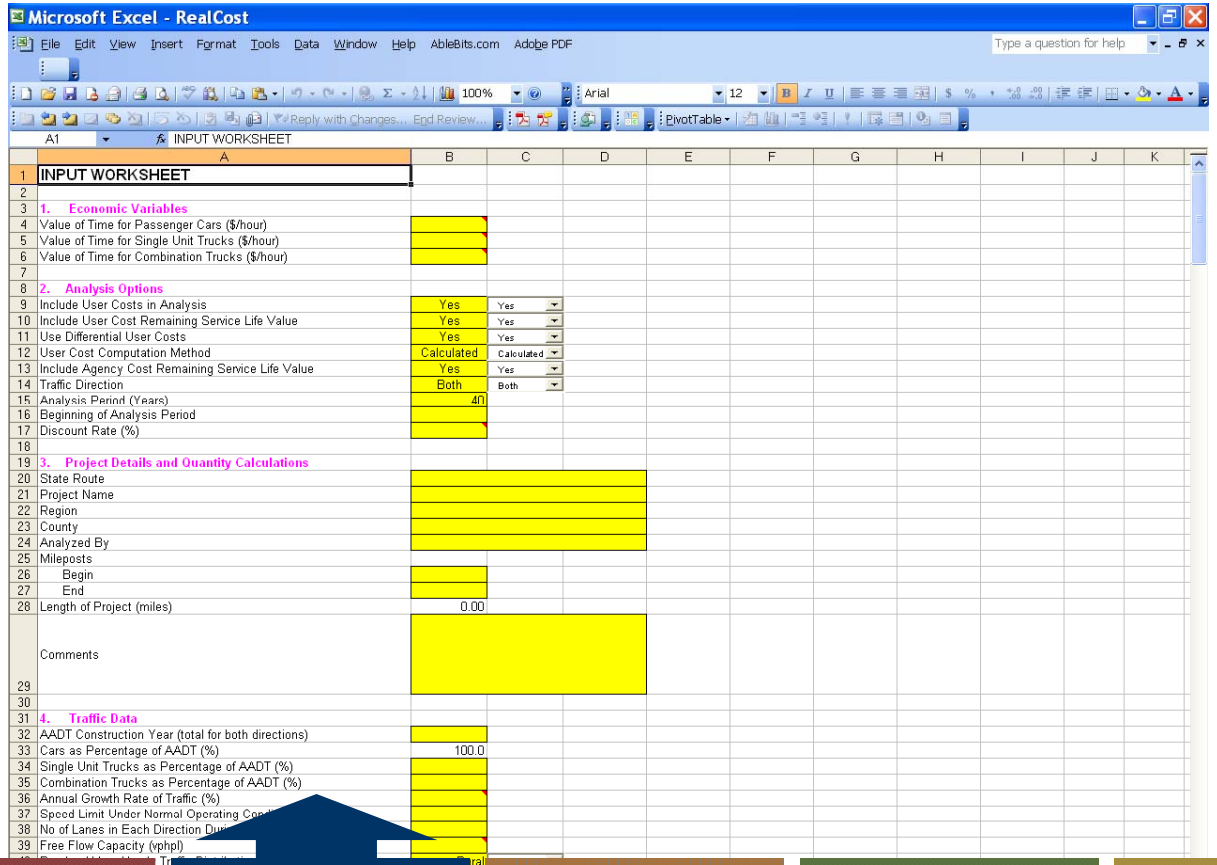
Life-Cycle Cost Analysis Software

RealCost™

Probabilistic Life-Cycle Cost Analysis

http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm



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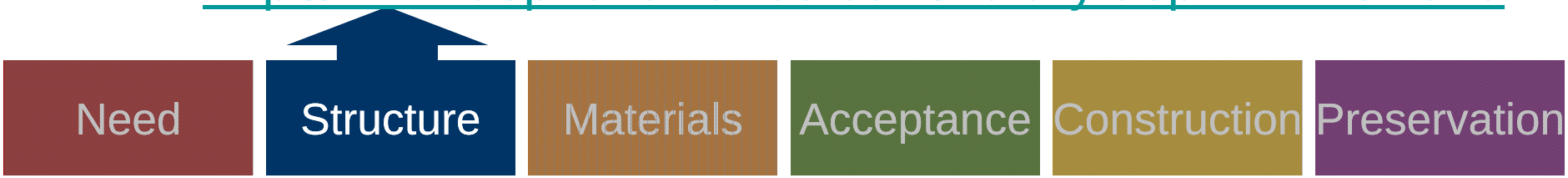
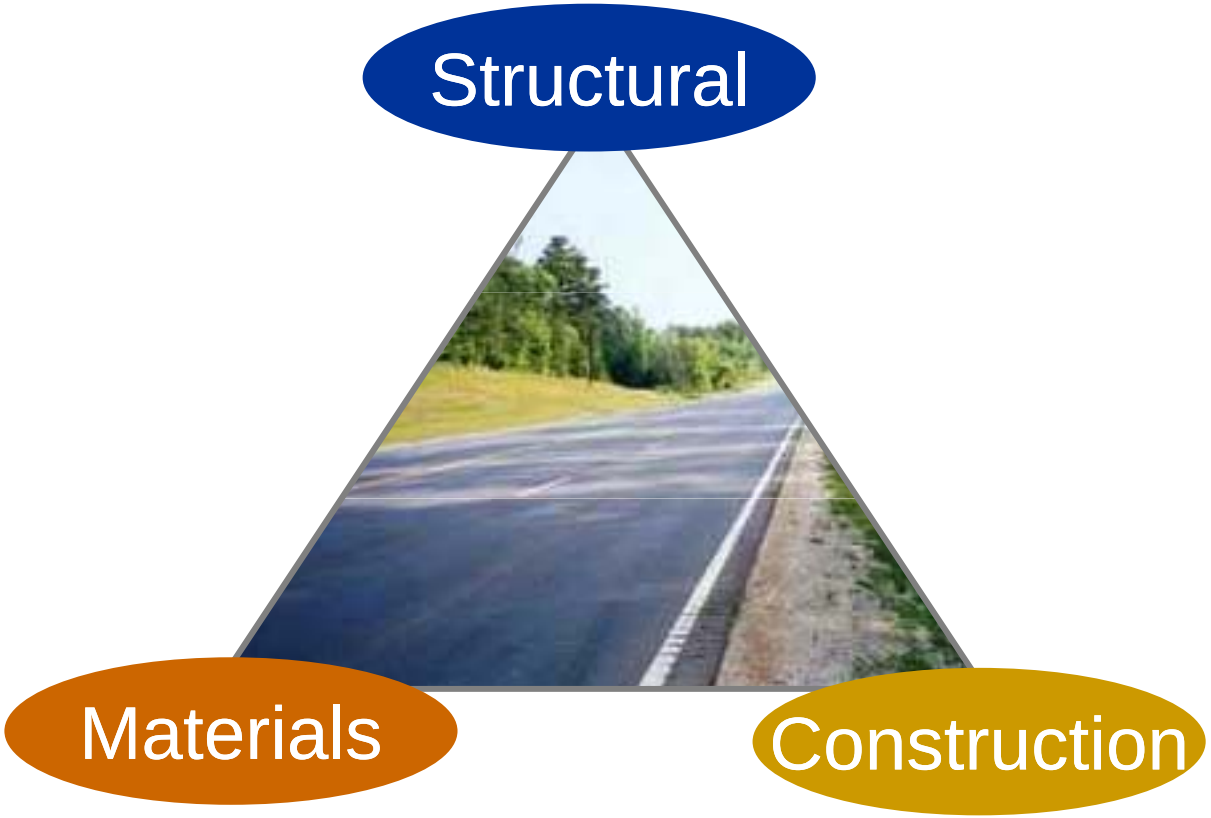
Pavement Design Resources

- FHWA:
  - http://www.fhwa.dot.gov/pavement/
- NCHRP, 1-37A: Free software download
  - http://www.trb.org/mepdg/
- National Asphalt Pavement Association
  - http://www.hotmix.org/
- Asphalt Pavement Alliance (APA)
  - http://www.asphaltalliance.com/index.asp
- APA: Perpetual Pavements
  - http://www.asphaltalliance.com/library.asp?MENU=519



Balancing Risk & Assuring Performance



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Balancing Risk & Assuring Performance

Superpave®

Performance-Based
Purchase Specification
Design and Analysis Tool

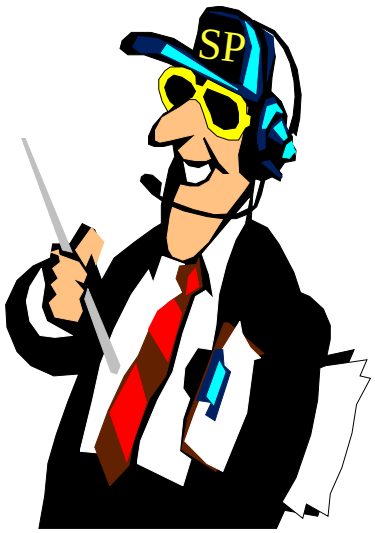
Need | Structure | Materials | Acceptance | Construction | P… n

Why SHRP?

- In the 1980's procedures and practices could not assure performance.
- **Unacceptable Risk**
- Distress…
  - Rutting
  - Fatigue cracking
  - Low-temperature cracking

Major Steps in Superpave Mix Design

1. Selection of Materials,
2. Selection of a Design Aggregate Structure,
3. Selection of the Design Binder Content,
4. Evaluation of Moisture Sensitivity of the Design Mixture, and
5. Performance Characterization.



Superpave Gyratory Compactor

ONGOING

Refinement

- **Understanding Modifiers, PGx**
- **Asphalt Mix Performance Tester**
- *Equipment Calibration*
- *Understanding acid*
- *Improved moisture test*

- Construction Quality
- Link to Pavement Design
- Communication!

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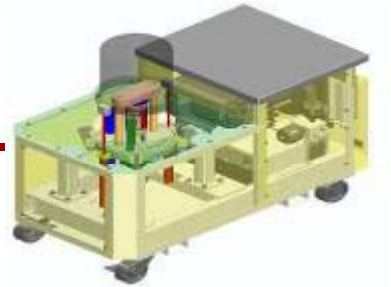
Paul Mack

New York State - Retired

Imperfection should never stall implementation.

You can still drink from a chipped cup.

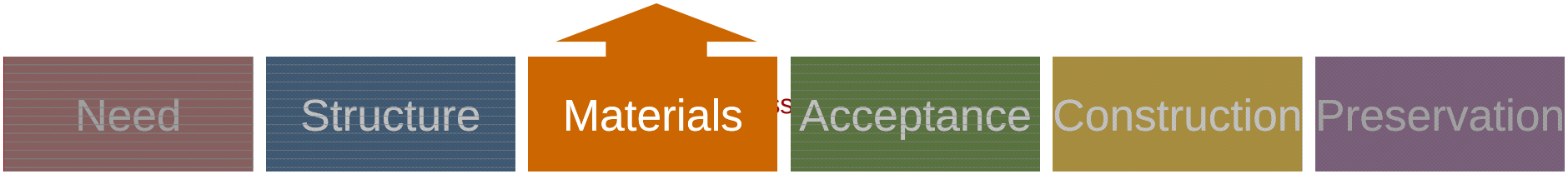
Challenges



- Achieving VMA
- Suitability of Gyratory Compaction Levels
- Issues of Durability & Binder content
- Need for a Moisture Sensitivity Test
- Deployment of a Performance/Strength Test

NCHRP 9 – Bituminous Materials

- RAP Characterization, 9-12
- Gyratory Level, 9-9, 9-16, 9-19
- Volumetric Requirements, 9-25, 9-31
- Performance Testing, 9-19, 9-29
- Mixture Design Manual, 9-33



New Asphalt Mix Performance Tester

AMPT

AMPT – Pooled Fund Study

- POC: Dr. Audrey Copeland, FHWA
  - Audrey.Copeland@dot.gov

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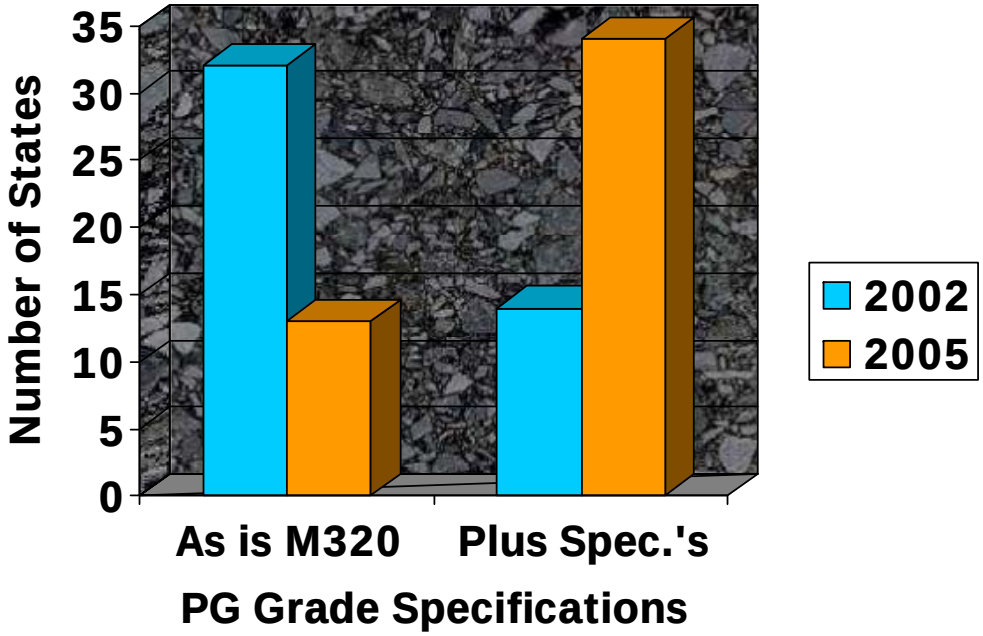
SHRP Asphalt Program Coordinator

Dr. Thomas Kennedy

"One of the principal goals of the ***SHRP*** asphalt program is to reduce or eliminate the proliferation of asphalt binder specifications."

Growing Trend from 2002 to 2005

- 34 States with Plus Specs (67%)
- 13 States Straight M 320
- 21 Different Pluses
- 4 Duel / Hybrid
- **The Winner! –**
  M 320 with 13 Pluses
  ++++++++++++++



Superpave® Plus

WHY?

High-Temperature Performance

I-80, Nevada

Same gradation - different binders.

PG 63-22 modified
No rutting

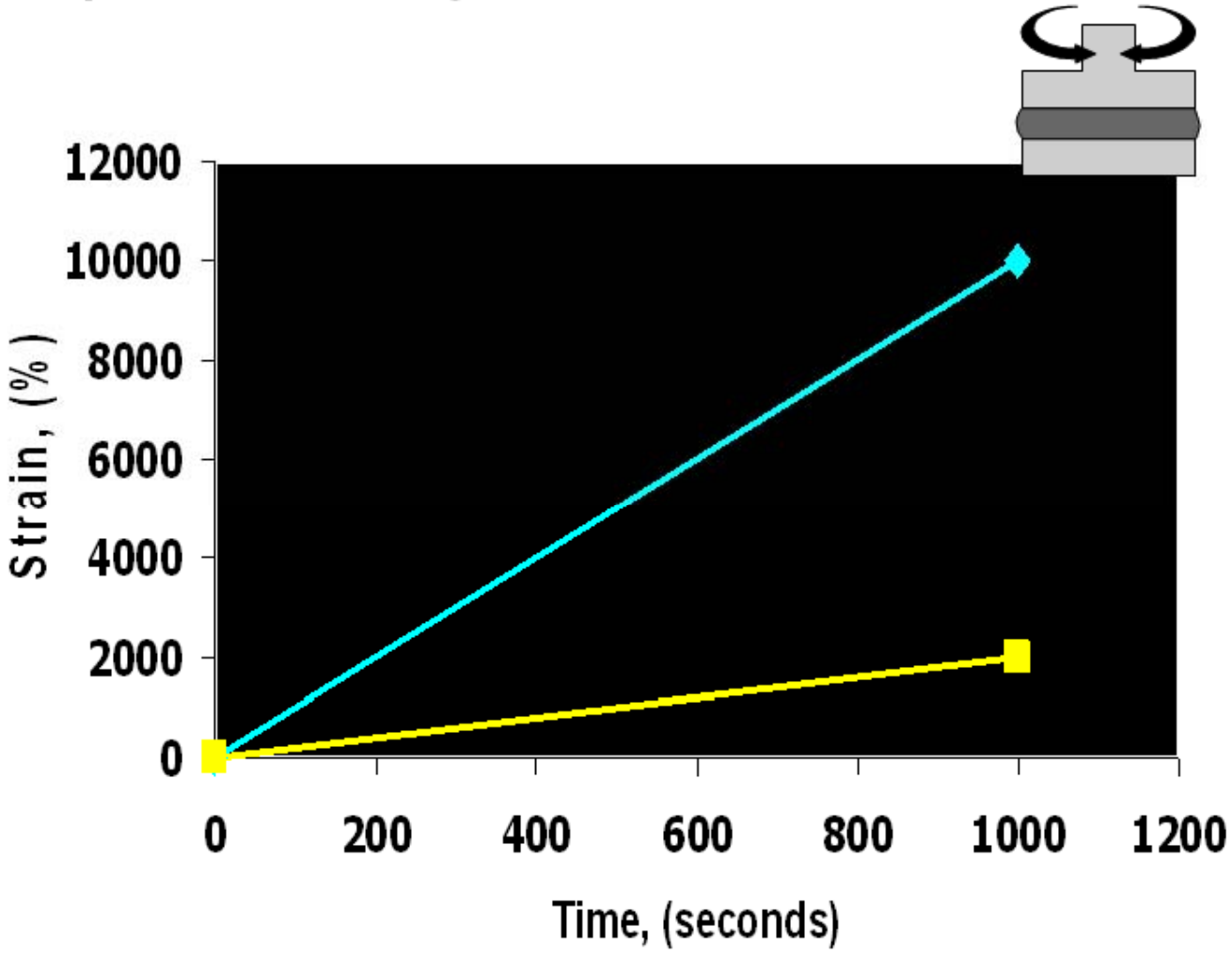
PG 67-22 unmodified
15mm of rutting

High Temperature (Rutting)

Repeated Creep Recovery Test

PG 67-22 Neat AC

PG 63-22 Modified

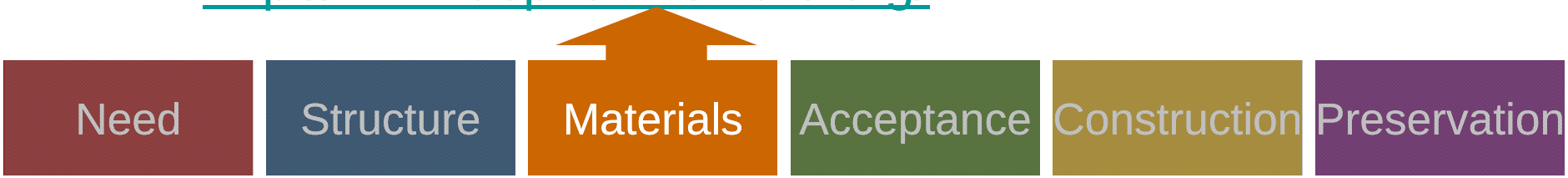


New Superpave Tool… PGx (Table 3)

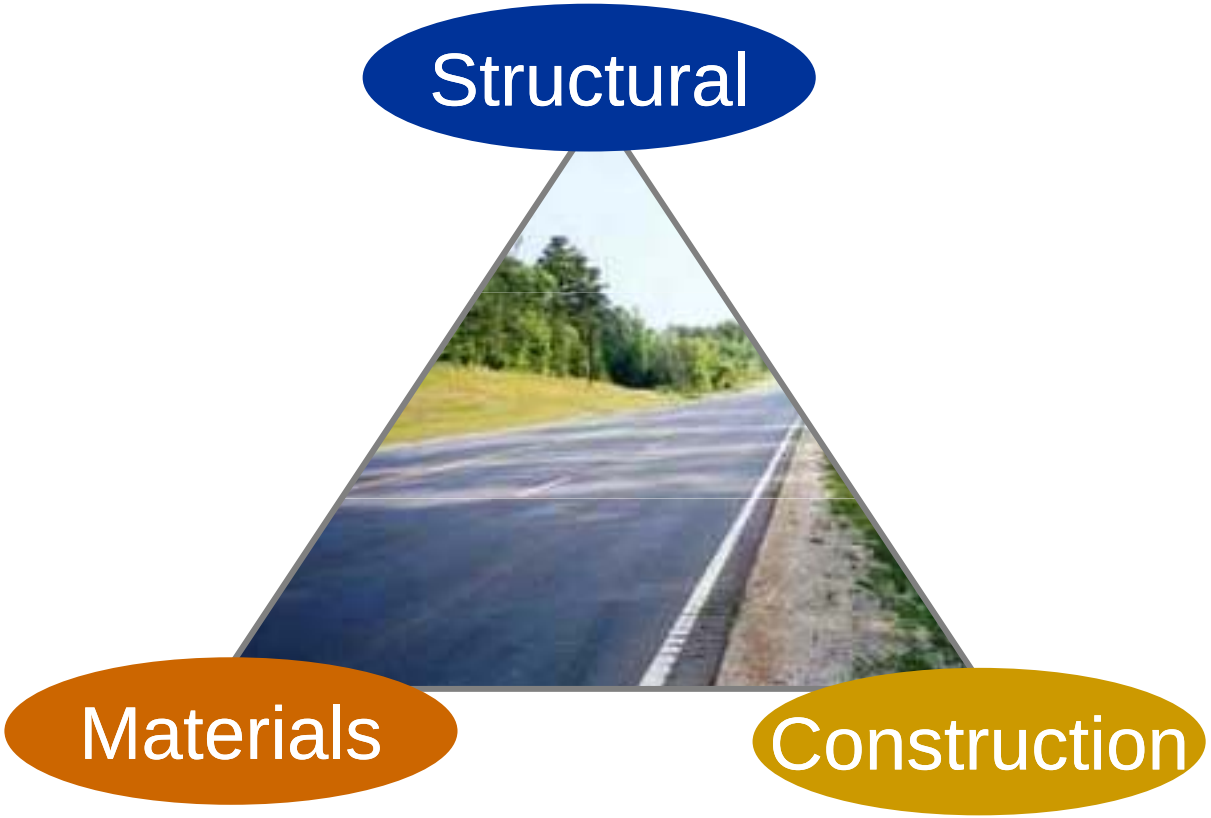
- Original Spec was based on Modulus, G* is Stress / Strain
- Compliance, J_{NR} is Strain / Stress
  - **x: Standard, Heavy, Very Heavy**
  - Eliminates grade-bumping
  - Accounts for traffic level through Jnr criteria

Materials Resources

- FHWA:
  - http://www.fhwa.dot.gov/pavement/
- NCHRP, 9-series
  - http://www.trb.org/mepdg/
- National Asphalt Pavement Association
  - http://www.hotmix.org/
- Asphalt Pavement Alliance (APA)
  - http://www.asphaltalliance.com/index.asp
- Asphalt Institute
  - http://www.asphaltinstitute.org/



Balancing Risk & Assuring Performance



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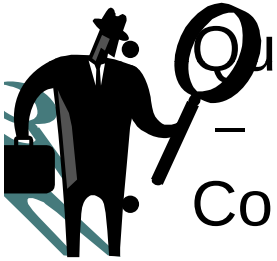
Construction

- *Contacting Mechanisms*
  - Design Standards (ex. Superpave) to Performance Specifications to Warranties to Public-Private-Partnership
- Quality Assurance Systems
  - Ex. Percent Within Limits (PWL)
- Compaction & Intelligent Construction Systems (ICS)
  - Longitudinal Joints, Automated Plants, IC Rolls, Infrared Cameras, Real time project information…
- Warm Mix Asphalt Technologies
- HIGH RAP Materials



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U.S. Department of Transportation
Federal Highway Administration

DRAFT

FHWA

Quality Assurance Assessment

FY 2008

What it is **NOT** and what it **IS**…

- The Assessment is NOT…
  - A “Gotcha”
  - A way to compare States
  - A indication of pavement performance
  - Perfect

- The Assessment is…
  - A tool to identify potential areas of RISK
  - A tool to identify “successful practices”
  - A tool to prioritize training
  - A tool to guide specification refinement

Driving Factors

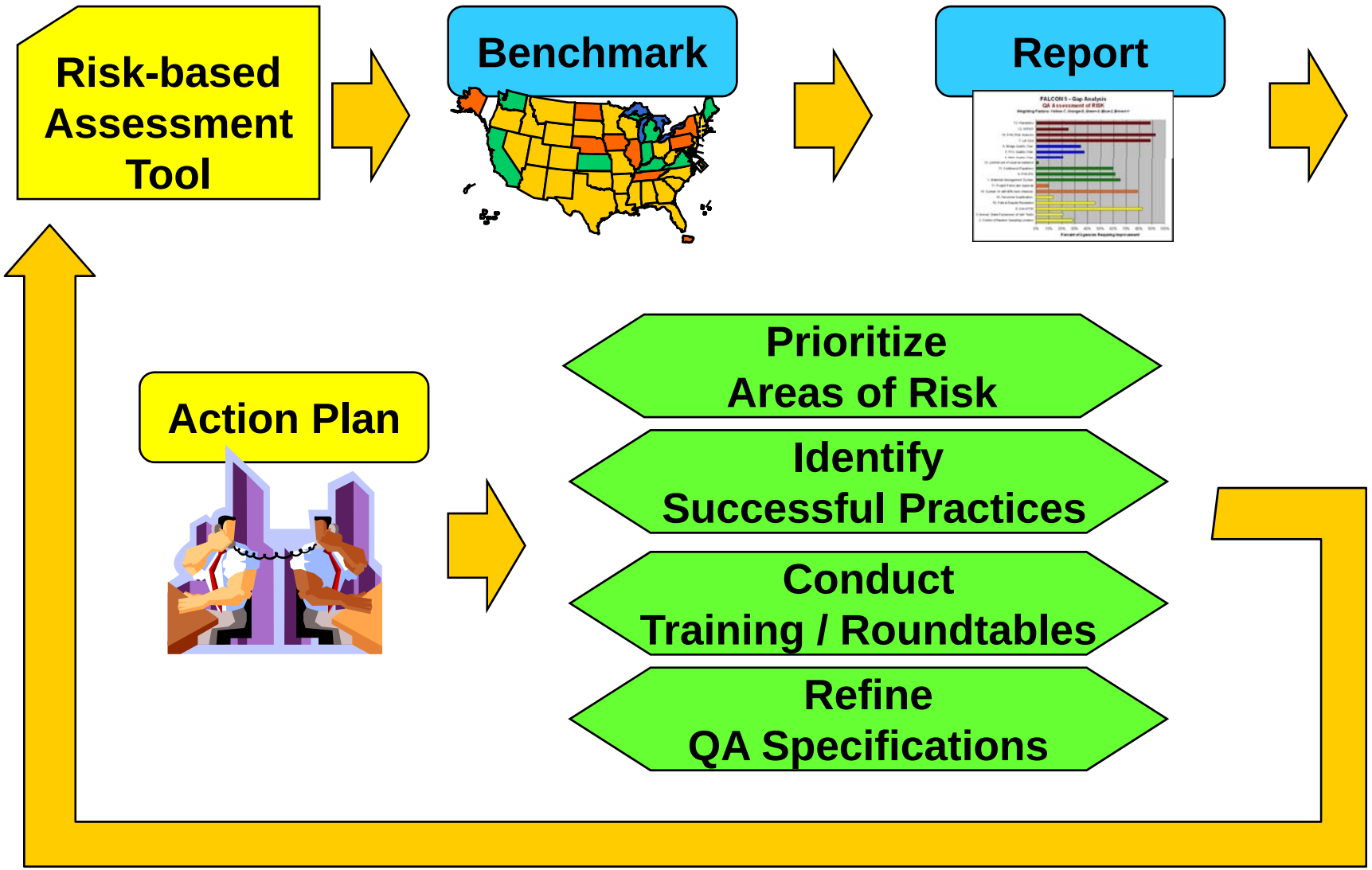
- Quality Assurance Reviews (HIPT)
  - State Agency Compliance with CFR
- National Review Program: Quality Assurance in Materials & Construction (Division Office Assessment of Risk)
  - Kevin McLaury (MT), Team Leader, Max Grogg (IA), Mike Praul (ME), Brad Neitzke (WFL), Ken Jacoby (HIAM), Pete Kulyk (HPC), & Tamiko Burnell (HSA)

National Review Program: Quality Assurance in Materials & Construction

Six Building Blocks…

1. Contractor Quality Control
2. Agency Acceptance
3. Independent Assurance
4. Dispute Resolution
5. Laboratory Accreditation and Qualification
6. Personnel Qualification/Certification, and
7. RISK

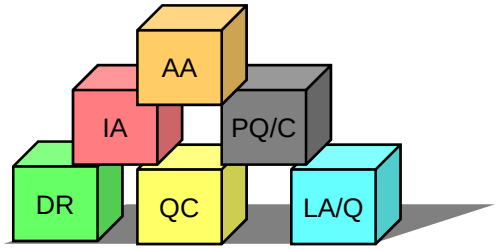
Risk-based Process

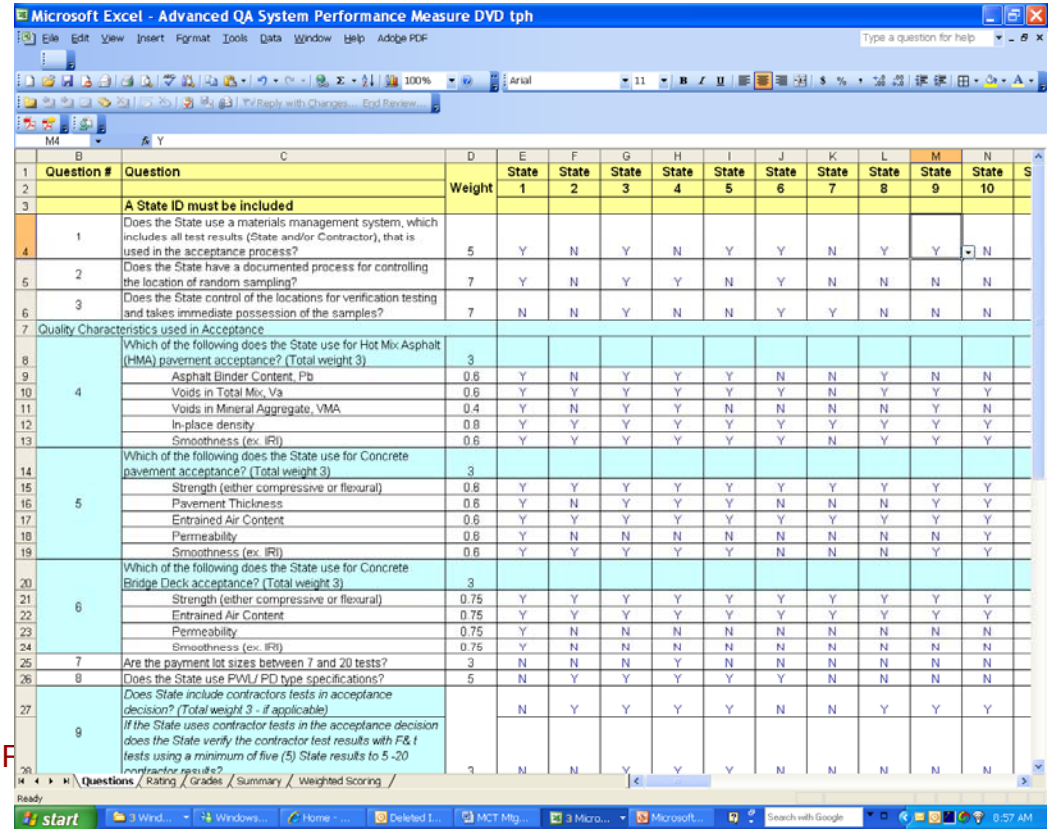


Division Office Interview *(Mike/Lee/Dennis)*
Assessment of RISK *(QA System)*

- 18 Questions…
  - Covers the Six Building Blocks
  - Questions Weighted
  - 1, 2, 3, 5, & 7

- Frequency
  - 52 in FY 2008
  - Updated… TBD

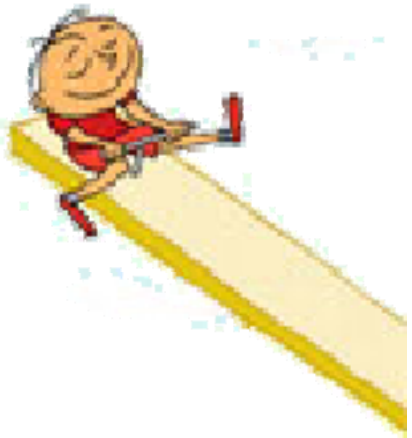


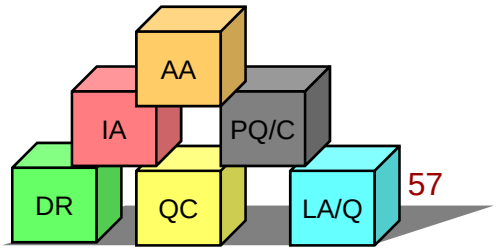

Microsoft Excel - Advanced QA System Performance Measure DVD tph

	Question #	Question	Weight	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9	State 10
3		A State ID must be included											
4	1	Does the State use a materials management system, which includes all test results (State and/or Contractor), that is used in the acceptance process?	5	Y	N	Y	N	Y	Y	N	Y	Y	N
5	2	Does the State have a documented process for controlling the location of random sampling?	7	Y	N	Y	Y	N	Y	N	N	N	N
6	3	Does the State control of the locations for verification testing and takes immediate possession of the samples?	7	N	N	Y	N	N	Y	Y	N	N	N
7	Quality Characteristics used in Acceptance												
8	4	Which of the following does the State use for Hot Mix Asphalt (HMA) pavement acceptance? (Total weight 3)	3										
9		Asphalt Binder Content, Pb	0.6	Y	N	Y	Y	Y	N	N	Y	N	N
10		Voids in Total Mix, Va	0.6	Y	Y	Y	Y	Y	N	N	Y	Y	Y
11		Voids in Mineral Aggregate, VMA	0.4	Y	N	Y	Y	N	N	N	N	Y	N
12		In-place density	0.8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13		Smoothness (ex. IRI)	0.6	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
14	5	Which of the following does the State use for Concrete pavement acceptance? (Total weight 3)	3										
15		Strength (either compressive or flexural)	0.8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16		Pavement Thickness	0.6	Y	N	Y	Y	Y	N	N	N	Y	Y
17		Entrained Air Content	0.6	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
18		Permeability	0.8	Y	N	N	N	N	N	N	N	N	Y
19		Smoothness (ex. IRI)	0.6	Y	Y	Y	Y	Y	N	N	N	Y	Y
20	6	Which of the following does the State use for Concrete Bridge Deck acceptance? (Total weight 3)	3										
21		Strength (either compressive or flexural)	0.75	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
22		Entrained Air Content	0.75	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
23		Permeability	0.75	Y	N	N	N	N	N	N	N	N	N
24		Smoothness (ex. IRI)	0.75	Y	N	N	N	N	N	N	N	N	N
25	7	Are the payment lot sizes between 7 and 20 tests?	3	N	N	N	Y	N	N	N	N	N	N
26	8	Does the State use PWL/ PD type specifications?	5	N	Y	Y	Y	Y	Y	N	N	N	N
27	9	*Does State include contractors tests in acceptance decision? (Total weight 3 - if applicable)*		N	Y	Y	Y	Y	N	N	Y	Y	Y
		If the State uses contractor tests in the acceptance decision does the State verify the contractor test results with F& t tests using a minimum of five (5) State results to 5 -20 contractor results?	3	N	N	Y	Y	Y	N	N	N	N	N

Two desired outcomes…

- We get what we pay for… Balanced, low-risk system
- Create a culture of Trust

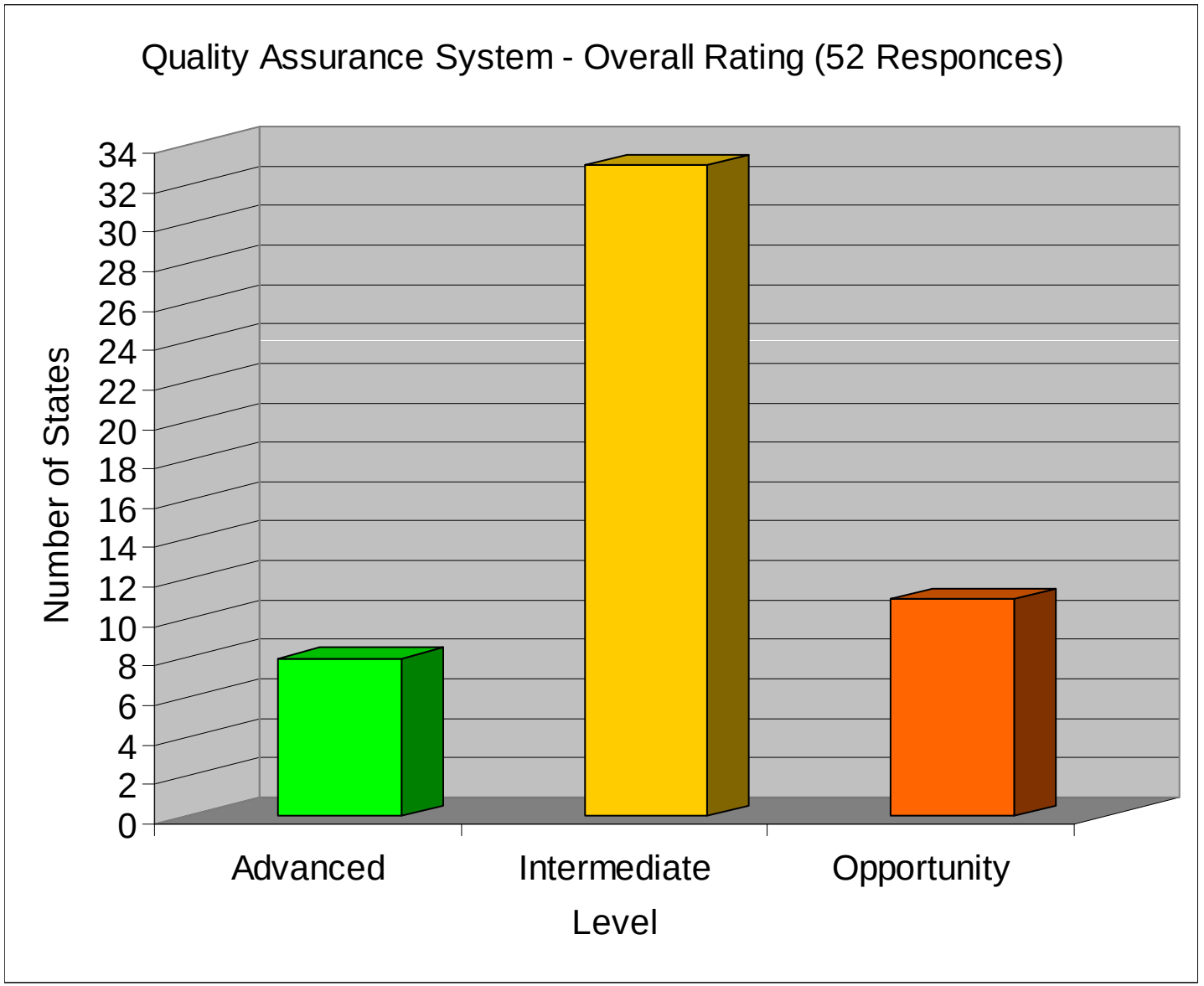




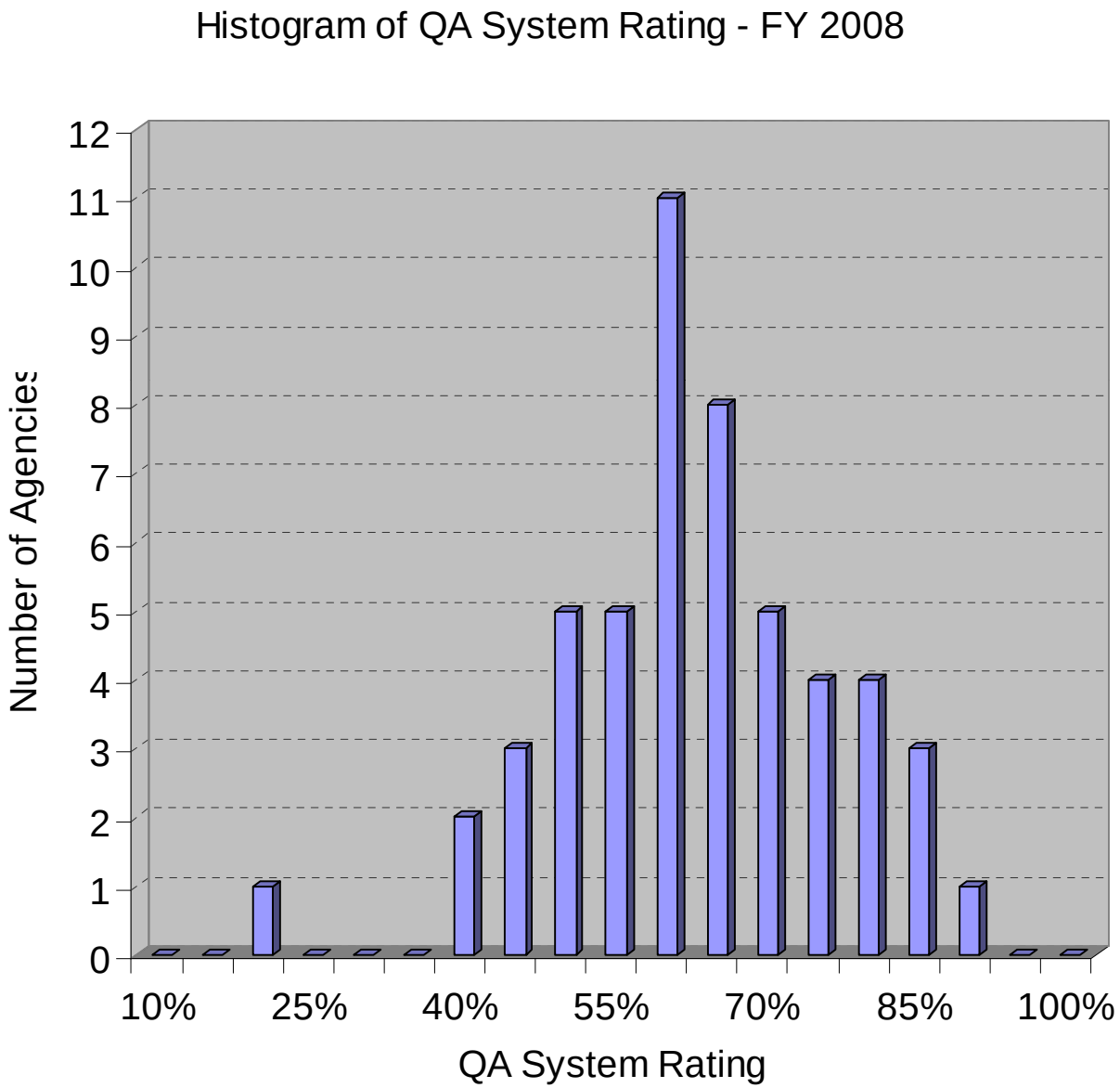
Definitions

- **Advanced States**
  - Those States that have highly developed QA programs that demonstrate their capability for measuring the quality of their construction and materials programs. An advance QA program includes highly developed Contractor Quality Control, Agency Acceptance, Dispute Resolution, Independent Assurance, Technician Certification or Qualification, and Laboratory Certification programs.
- **Intermediate States**
  - Those States that have substantially demonstrated an effective QA program for measuring quality and includes most of the QA elements of an advanced QA program.
- **Opportunity States**
  - Those States that have a demonstrated a weakness in their construction and materials programs to measure quality or have a weakness in their program that could lead to fraud.

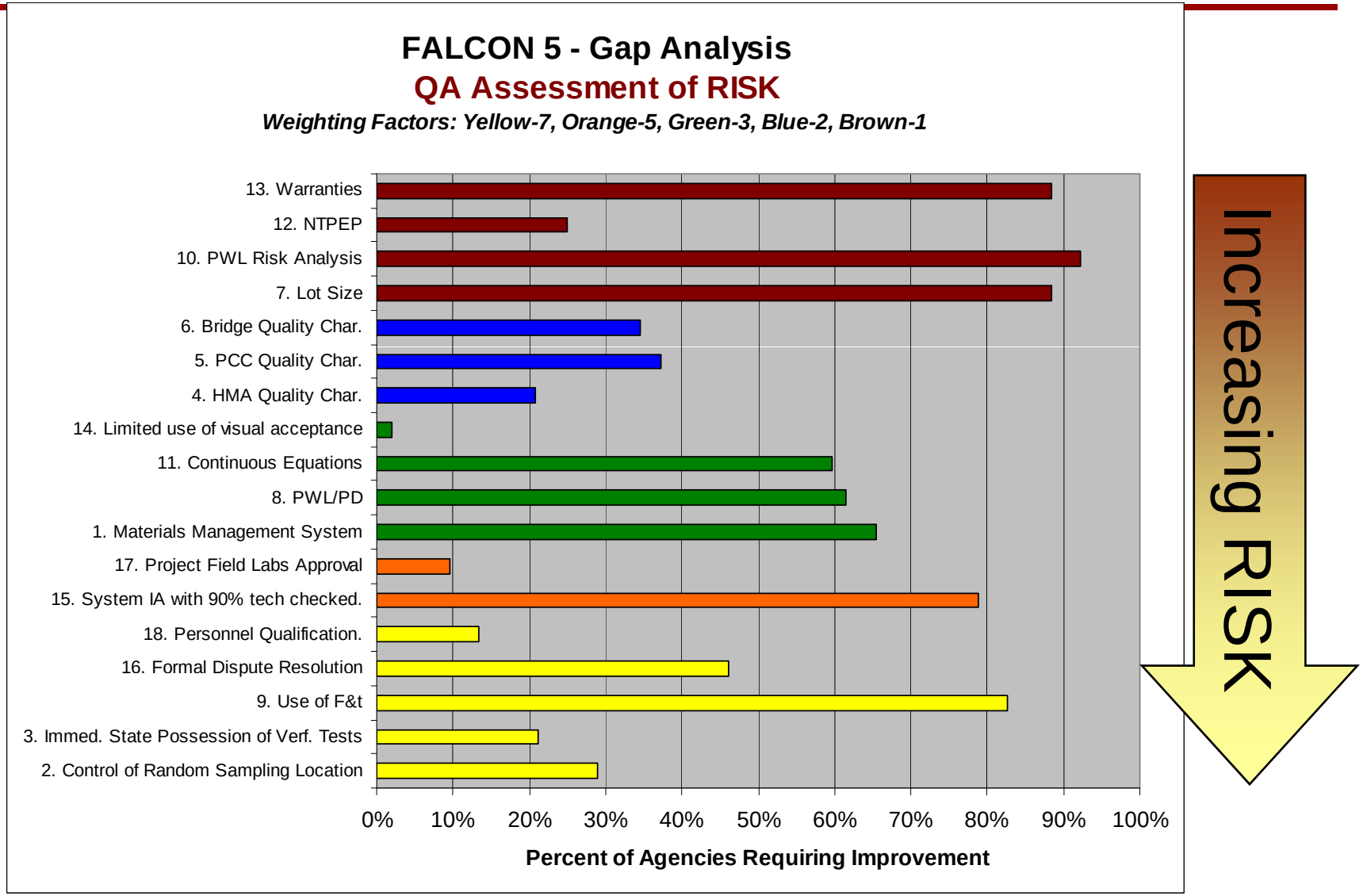
NPM – A low rating is not a compliance issue with 23 CFR 637.



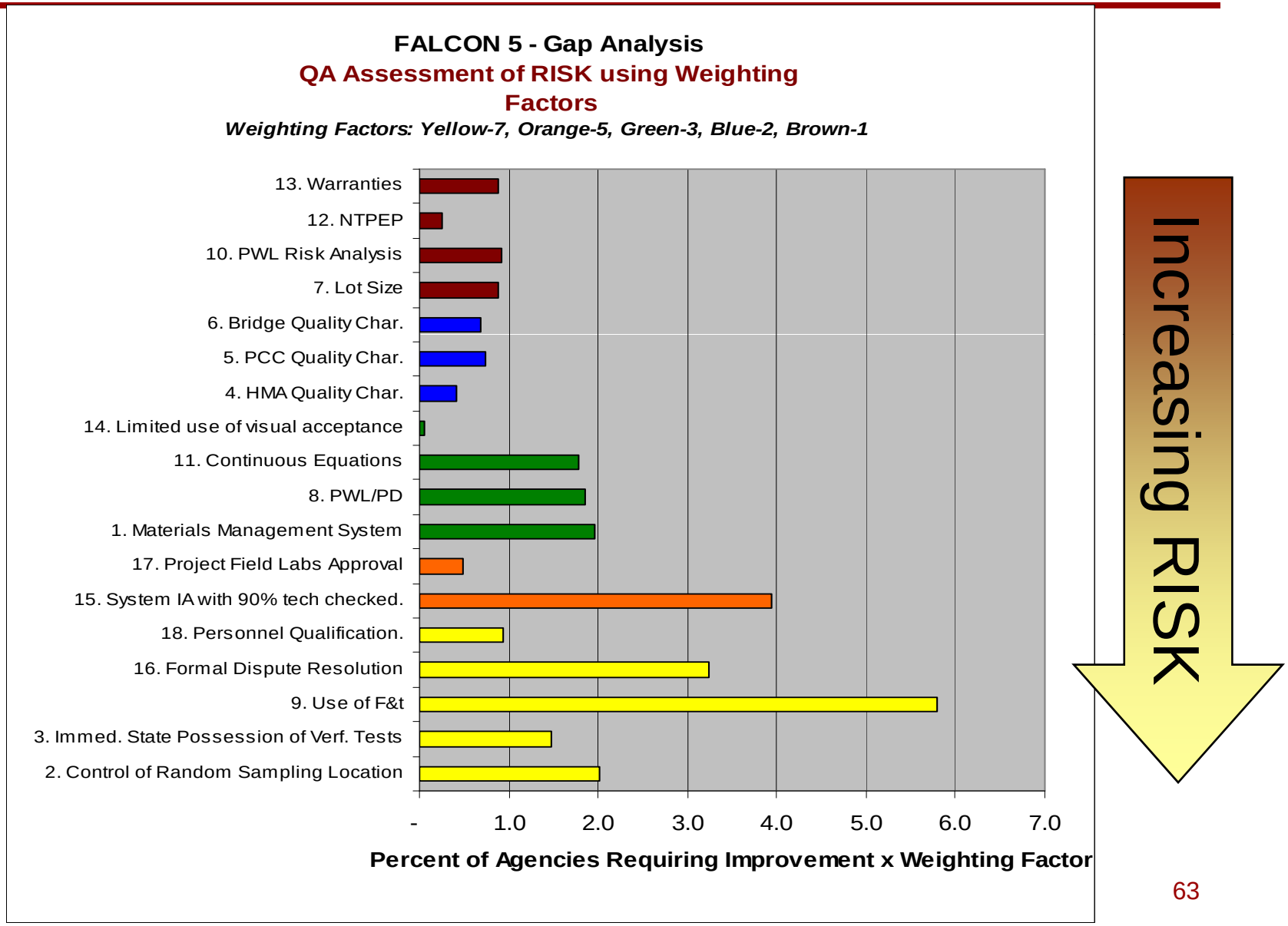
Distribution of Rating



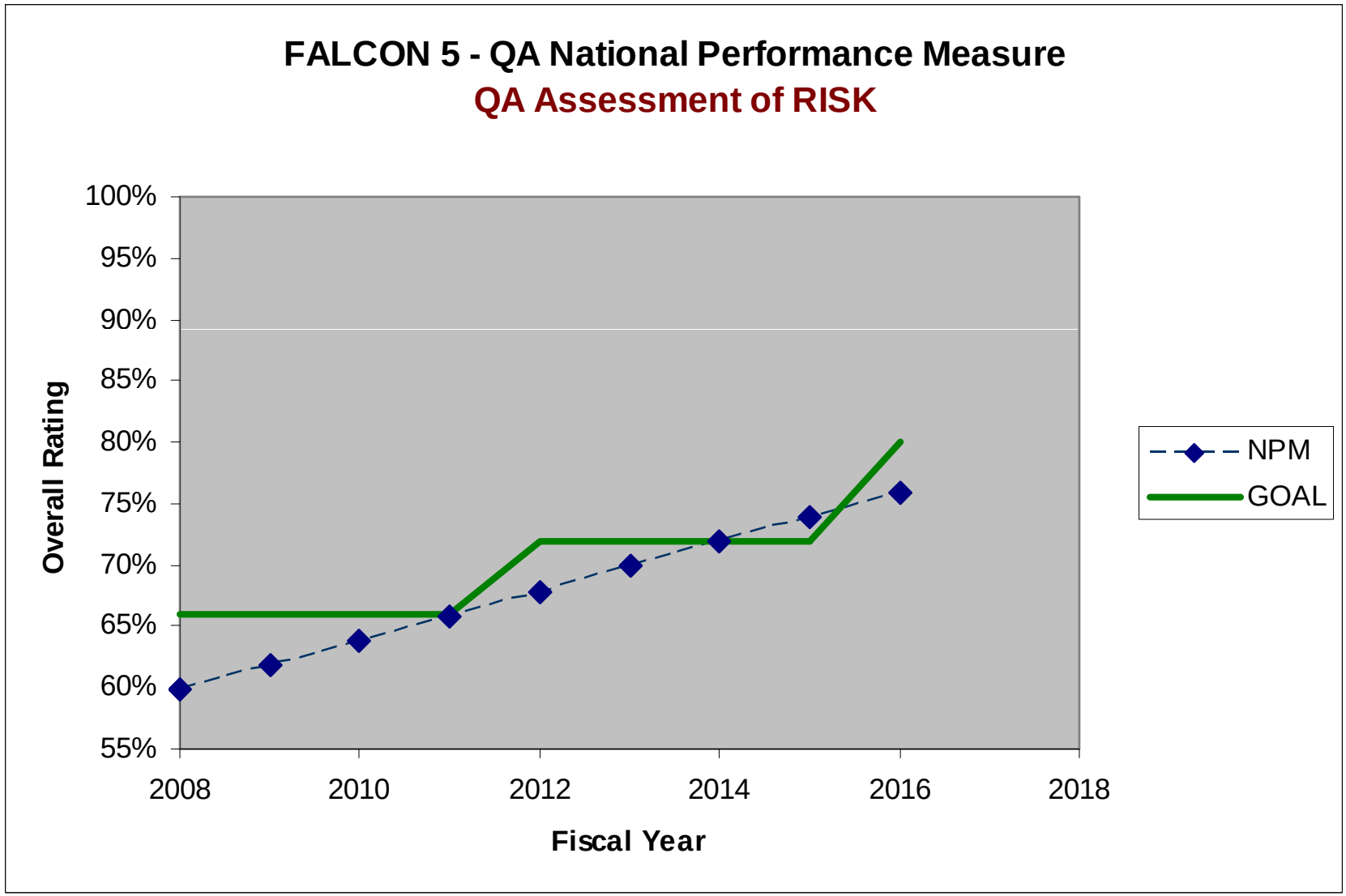
% of Agencies Needing Advancement



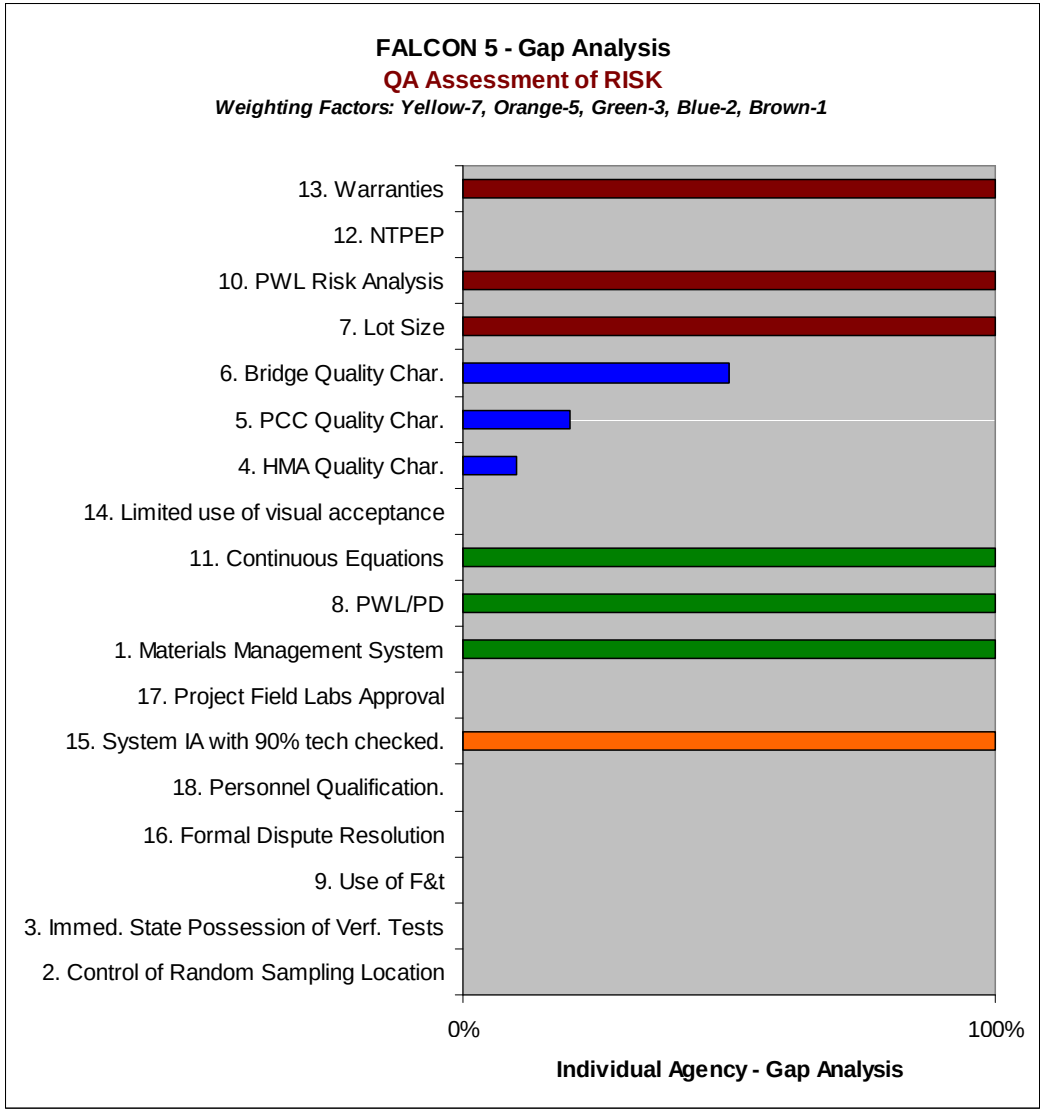
x Weighting Factor



National Performance Measure (SIP)



Gaps for Average Division Office



General Risk Areas

Moderate Risk Areas

Higher Risk Areas

Activities to Address Gaps

Risk Areas Identified

Q-7 (Lot Size)

Q-8 (PWL/PD)

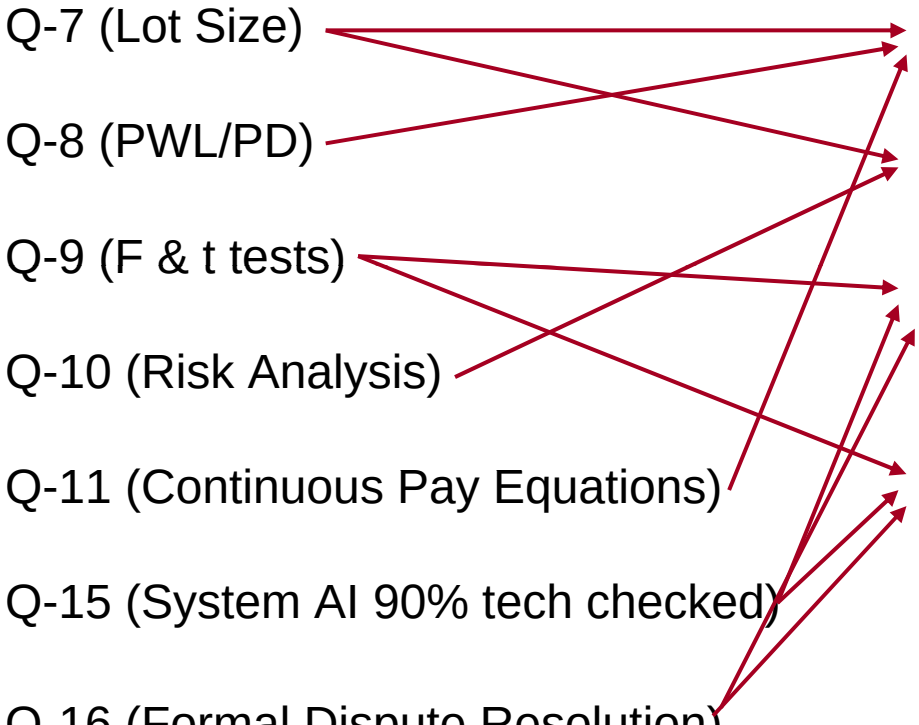
Q-9 (F & t tests)

Q-10 (Risk Analysis)

Q-11 (Continuous Pay Equations)

Q-15 (System AI 90% tech checked)

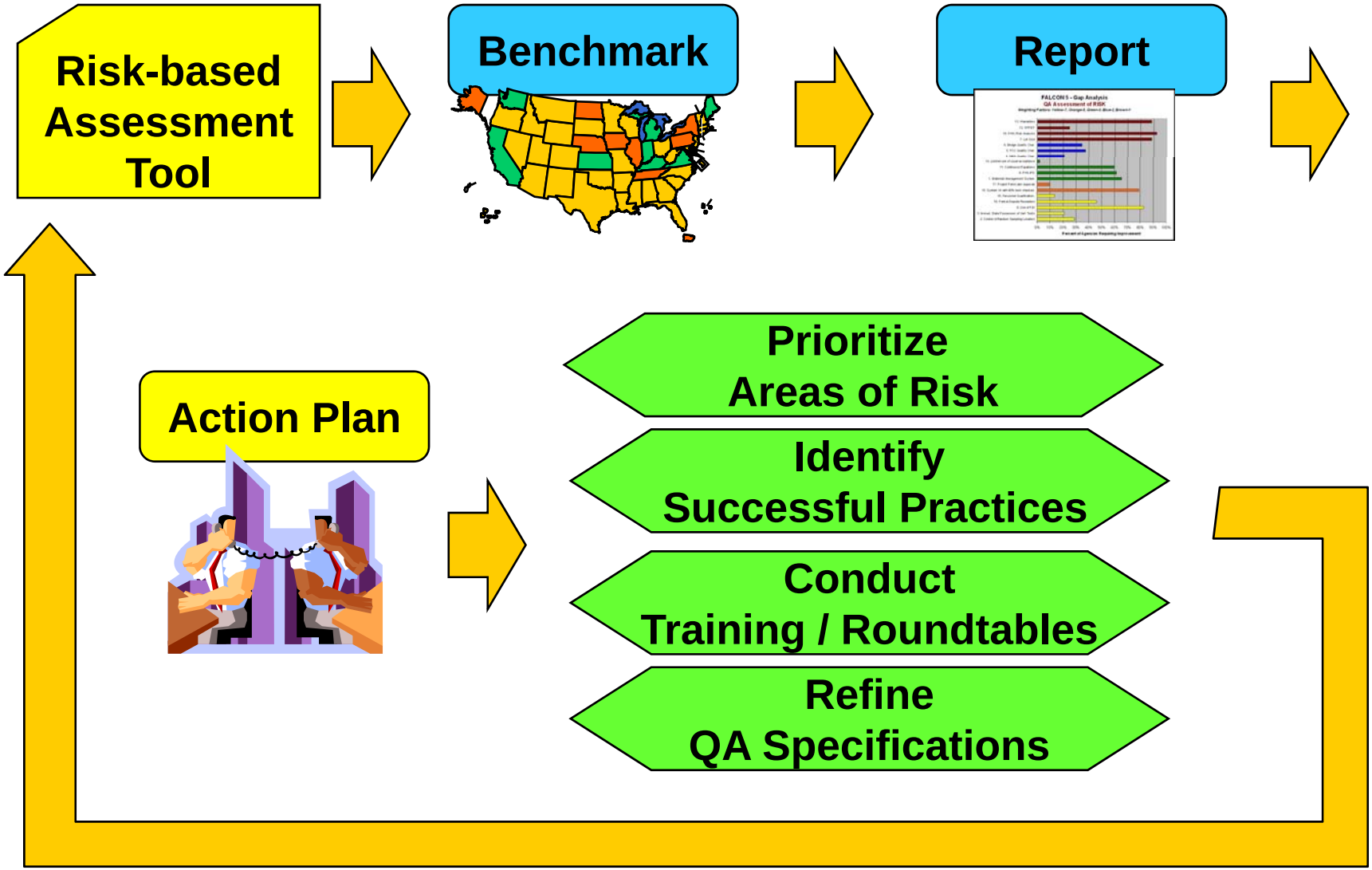
Q-16 (Formal Dispute Resolution)



Products & Services

- ❑ PWL Workshop
- ❑ SpecRisk Workshop
- ❑ Topical web-based manual on Quality Assurance
- ❑ Quality Assurance for Field Engineers training course
- ✓ Provide Examples of SUCCESSFUL PRACTICES

Risk-based Process



Intelligent Construction Systems

Reducing Risk

100% Sampling

Link to PMS

Intelligent Compactors

(aka Smart Rollers)

- Soils and Asphalt
- Intelligent
  - Measures a parameter that relates to performance (density/stiffness)
  - Adjusts compaction effort based on measure response
  - Provides real-time graphical information
  - Records response tied to location (GPS)

HMA Compaction

Good Performing Longitudinal Joints are not an "Accident!"

6 year old pavement

® Courtesy of A Heritage Group Company

Low Density Joint

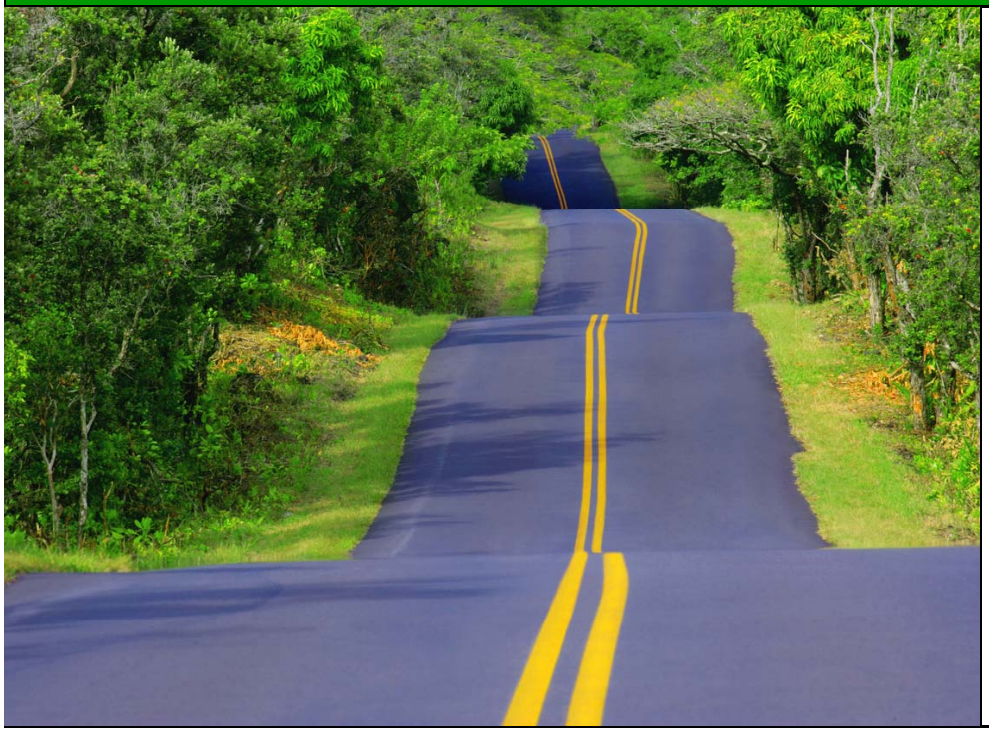
Day after a hard rain –
Trapped Moisture

1 year old pavement

Low Density Joint

National RAP Expert Task Group

HMA Asphalt Pavement Recycling Expert Task Group



Advance the use of RAP in asphalt paving applications by providing highway agencies with critical information regarding the use of RAP, technical guidance on high-RAP projects, and direction on research activities.

The members consist of representatives from highway agencies, industry, and academia.

Website: www.ncat.us/rap/rap

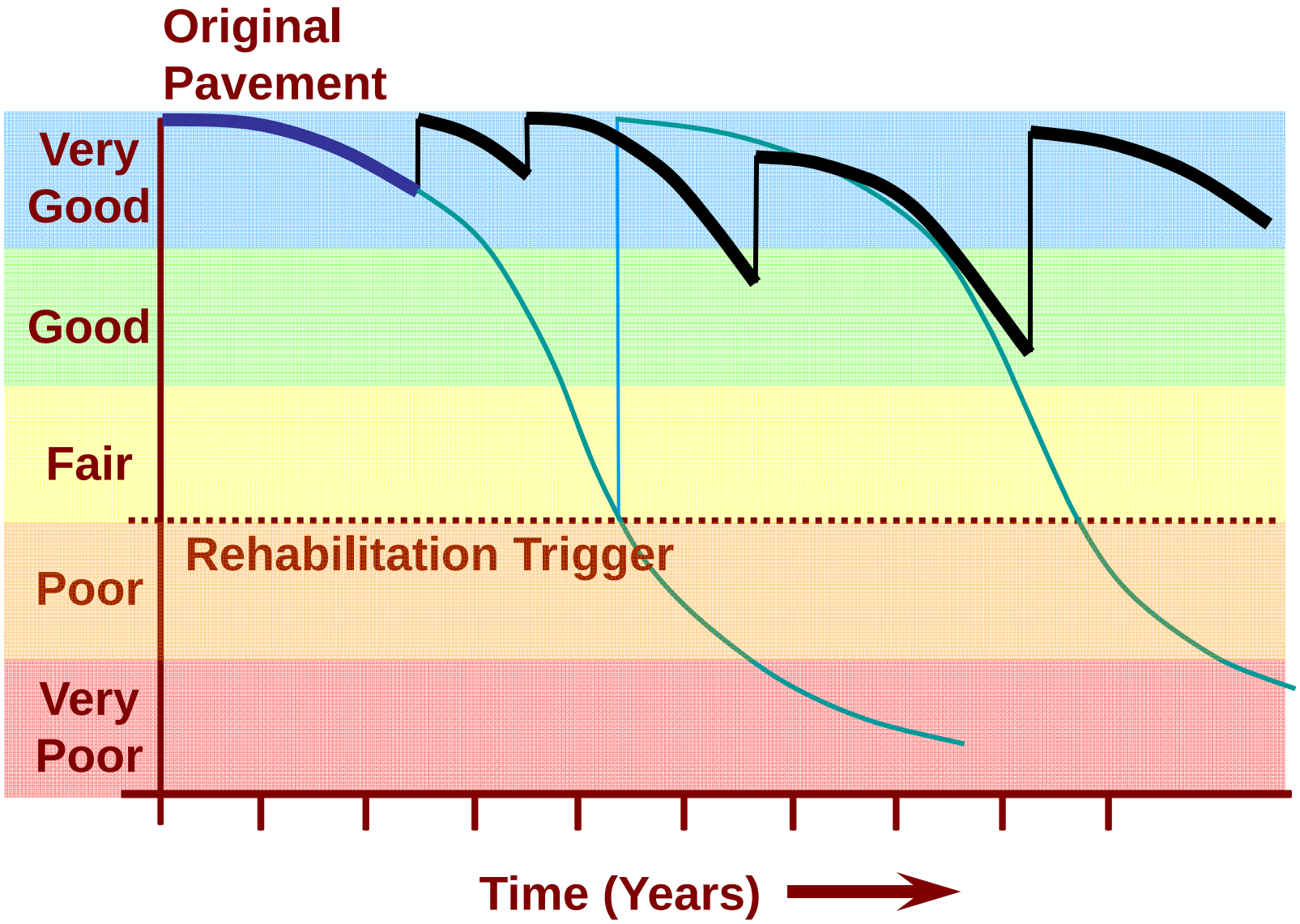
National Center for Asphalt Technology NCAT at Auburn University

RAP Resources

- New Expert Task Group on High RAP
- FHWA
  - www.fhwa.dot.gov/pavement/recycling
- Recycled Materials Resource Center
  - www.rmrc.unh.edu
- Green Highways Partnership
  - www.greenhighways.org
- FHWA R&D
  - http://www.tfhrc.gov/hnr20/recycle/waste/index.htm

The Pavement Preservation Concept

Thinking about tomorrow to drive today's decisions



Acceptance & Construction Resources

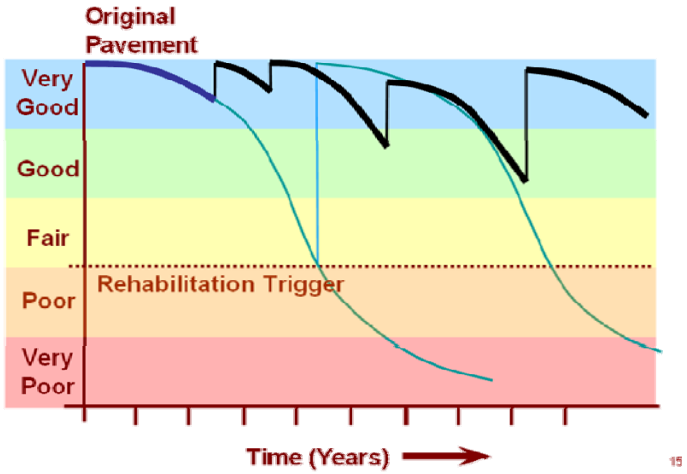
- FHWA: Asset Management
  - http://www.fhwa.dot.gov/infrastructure/asstmgmt/index.htm
- National Asphalt Pavement Association
  - http://www.hotmix.org/
- Asphalt Pavement Alliance (APA)
  - http://www.asphaltalliance.com/index.asp
- Asphalt Institute
  - http://www.asphaltinstitute.org/
- Foundation for Pavement Preservation
  - http://fp2.org/

Balancing Risk & Assuring Performance

Structural

Materials

Construction



15

Need | Structure | Materials | Acceptance | Construction | Preservation

Risk and Innovation

- Systems like Superpave reduces the Risk of poor pavement performance, and

- Are adapting to address innovative materials and other evolving technologies.

Questions?