Workshop Lectures on Pavements

28 September 2006 Thursday

- **Lecture 1: Pavement Management Functions and Data Needs**
- Lecture 2: Pavement Assessment and Overlay Design –1
- Lecture 3: Pavement Assessment and Overlay Design –2
- Lecture 4: Network-level Pavement Management – I
- Lecture 5: Network-level Pavement Management – II
- Lecture 6: Network-level Pavement Management – III

29 September 2006 Friday

- Lecture 7: Life-cycle analysis (LCA) of Costs and Benefits
- Lecture 8: Value Engineering (VE) in Transportation Projects
- Lecture 9: Value Engineering (VE) – DOT Case Study
- Lecture 10: Remote Sensing for Sustainable Infrastructure Development and Disaster Impact Assessment

Workshop Lectures on Pavements

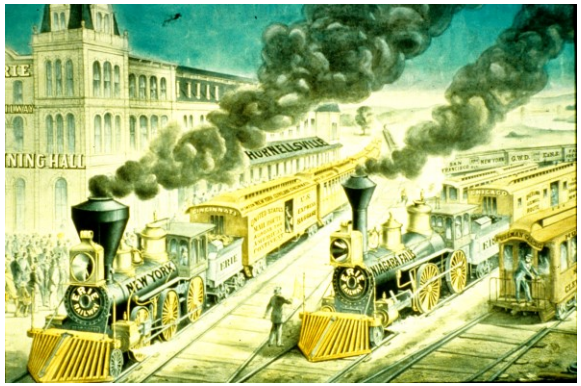
28 September 2006 Thursday

- **Lecture 1: Pavement Management Functions and Data Needs**

TOPICS:

- **Pavement needs and funding issues**
- **Pavement Management System (PMS) overview**
- **Design, construction, maintenance, and rehabilitation effects on pavement performance**
- **Monitoring and evaluation technologies (functional, structural)**
- **Data needs at project-level versus network-level**
- **Costs and benefits of PMS.**

Road building, BC era, 1400-1800, early 1990's, post World War II, AASHO Road Test, Modern era of Pavement Management (PM)

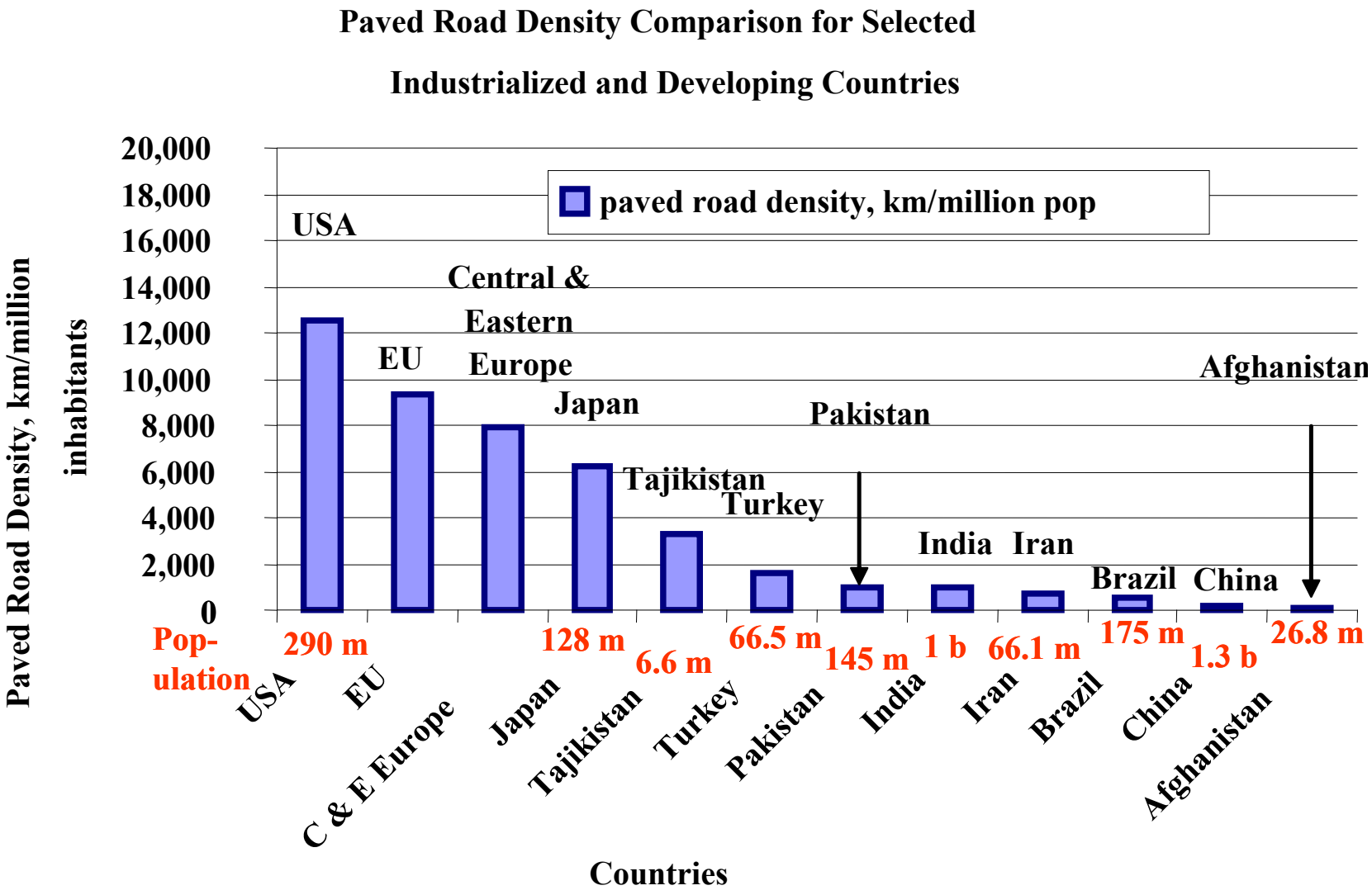


Status of the U.S. Highway Network

- 46,610 miles of Interstate
- 3.9 million miles of state and local roadways
- Public invested more than $130 billion to construct the Interstate System in the 1960's and 1970's
- Think of the total investment in all public roads and streets . . . (over $1.75 trillion)
- Annual travel is estimated to be over 2.7 trillion vehicle-mile/year
- Serving 130 Million cars and 77 million trucks

Roads represent the largest public infrastructure investment (associated with economic prosperity).

Transportation Related Economic Benefits



Australia – Transportation Facts

- **Population 20,264,082 (July 2006)**
- **Roads 810,641 km (2004)**
  - **Paved: 336,962 km**
  - **Unpaved: 473,679 km**
- **Paved Road Density 16,630 km/million pop**

Source: CIA World Fact Book 2006

AASHO ROAD TEST, 1959-61

First time defined

* Pavement Failure

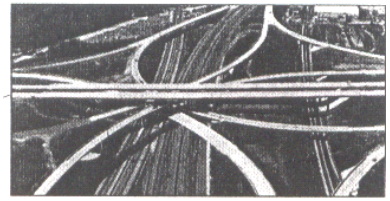
* Serviceability - Performance

Mixed Truck Traffic for Design Period Converted to ESALs

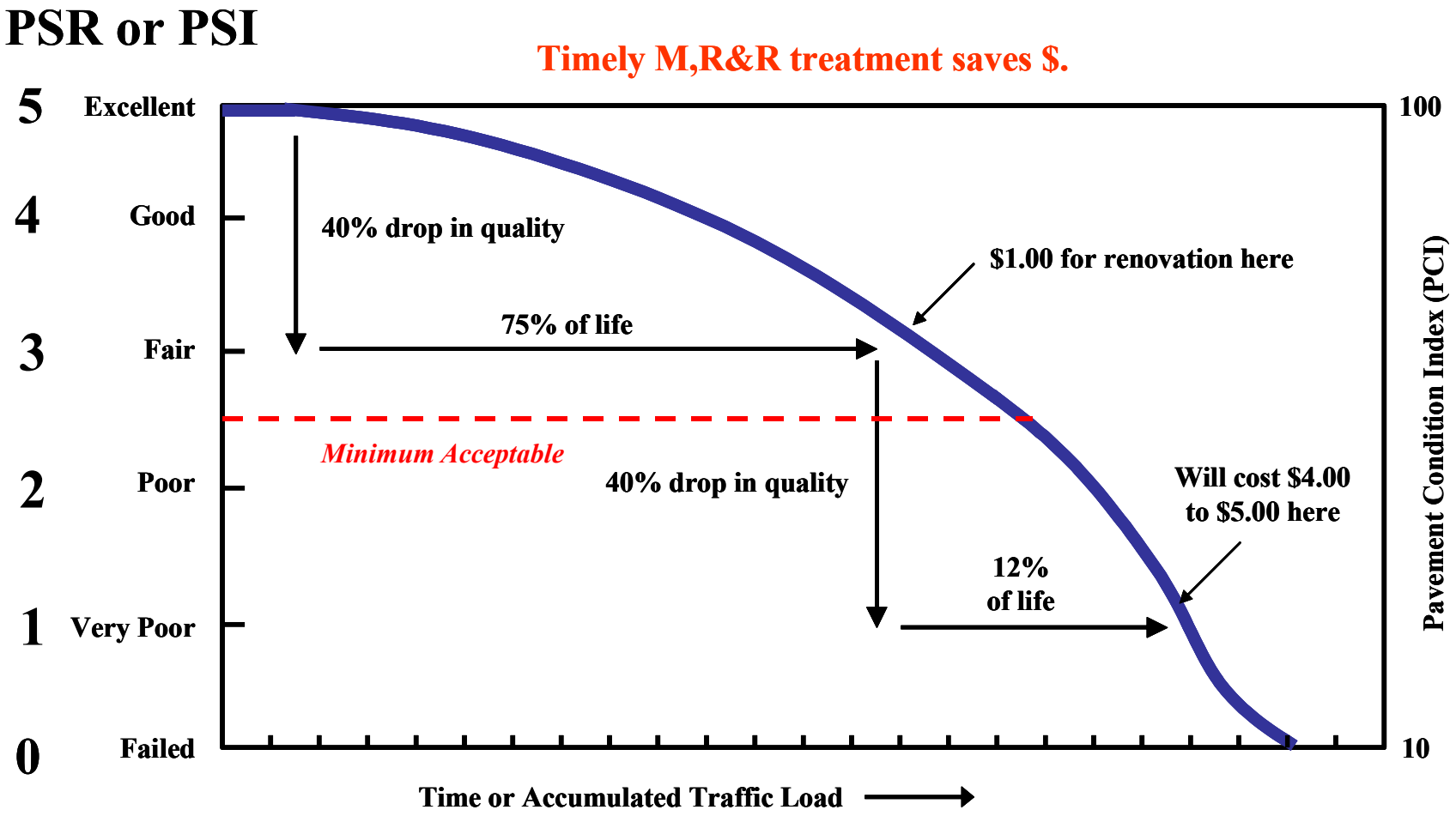
4th Power Law

Design of Pavement Structures

- To provide a stable and smooth riding surface **Functional Class**
- PSI (Present Serviceability Index); PSR
- To support heavy moving loads without excessive deflection or damage to pavement
- To support design load repetitions during the design life without **failure**
- Pavement structure (flexible or rigid)
- Improved materials on compacted subgrade, Layered (to be cost-effective), Thickness (functional class)
- **Design Inputs:** Traffic => Volume, % Truck, Annual Growth, ADT (Annual Average Daily Traffic), **Reliability**
  Subgrade soil strength => CBR, % or Resilient Modulus M_R , psi
  Environment => Precipitation, Temperature, Subgrade soil …



Pavement Performance Curves for Pavement Thickness Design and Life Cycle Cost Analysis



Design of Pavement Structures

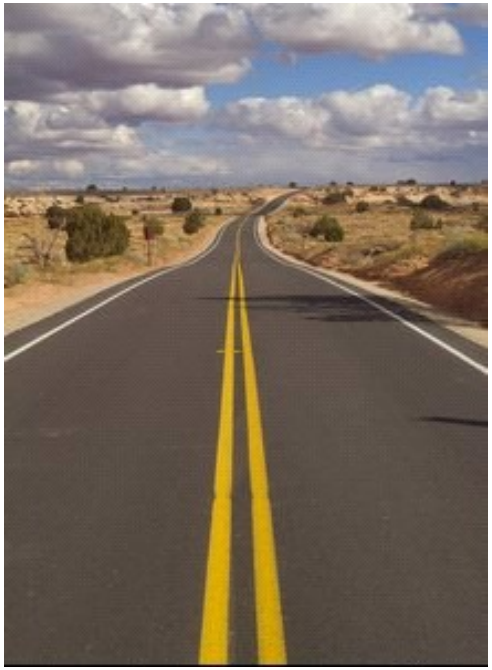
- **Pavement design methods (AASHTO, State highway agency methods, Asphalt Institute, PCA…)**
- **Pavement Design Outputs:**

  Design thickness of each layer above subgrade

  Thickness compatible with minimum construction thickness criteria

  Layer material type and selection/compaction criteria

  Asphalt is temperature-dependent viscoelastic material.



- **Design of drainage structures (surface & subsurface)**
- **Design of Shoulder (highways)**
- **Design of Sidewalk (urban roads and city streets)**
- **Construction details of concrete pavements**
- **Life-cycle cost analysis**

1980's onwards
Increased axle/wheel loads and tire pressure

Now: 10,000 kg wheel load and 1,500 kPa tire pressure on commercial jets

AASHO-Based highway pavement design good upto:

2,000 kg wheel load

500 kPa tire pressure

Factors Affecting Pavement Life

Load Factors

- Traffic loads
- Load repetitions

Non-Load Factors

- Environment
- Pavement materials
- Subgrade strength
- Maintenance Practice
- Construction quality
- Interaction terms

Asphalt is temperature-dependent viscoelastic material.

- **Queensland is described as the Sunshine State.**
- **Weighted Mean Annual Pavement Temperature varies between 28 and 36 degrees C.**
- **The state is divided into four Temperature Zones.**
- **Queensland Department of Main Road Technical Note 6 does not contain asphalt temperature correction graph for asphalt surfacings less than 50mm.**

6th International Conference on Managing Pavements

19-24 October 2004

Brisbane Convention & Exhibition Centre, Queensland Australia

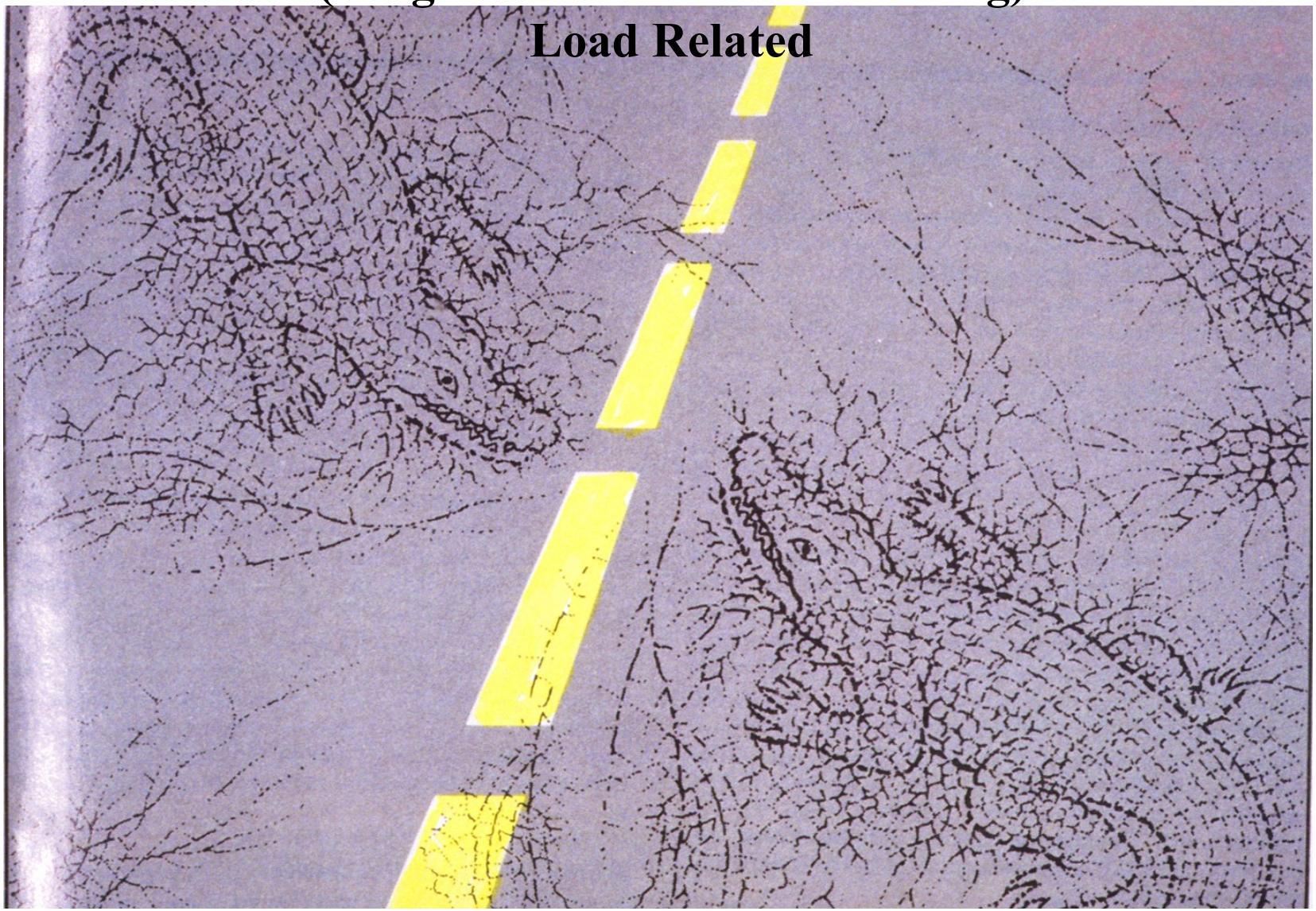
Load Related

Joint faulting and deterioration on concrete pavement increase Roughness

Load Related

Cracking, Rutting, and Patching increase Roughness in asphalt pavements

Asphalt Pavement, High Severity Fatigue Cracking (Alligator or Crocodile Cracking) Load Related



Distress Data (Defect Data)

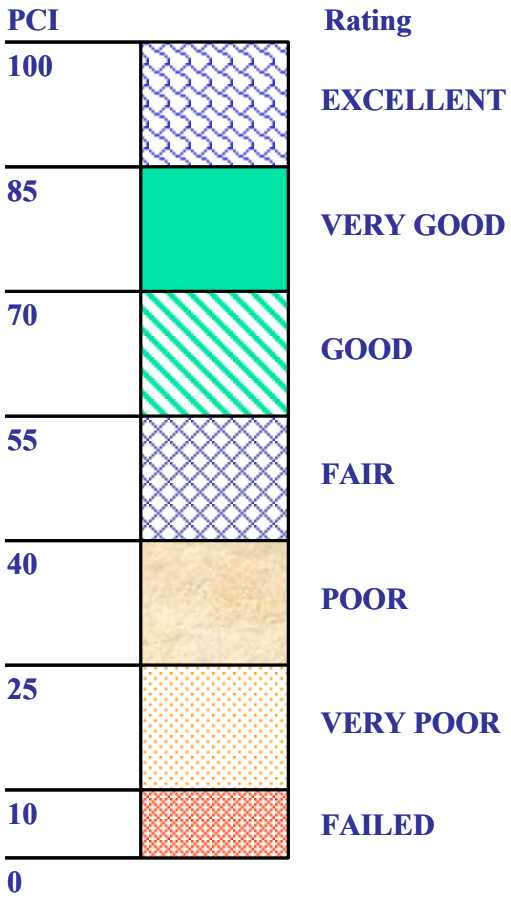
- Distress Type, Severity, Extent
- Measurement, Sampling
- Composite Distress Index

Environmental Related

Asphalt Pavement, Medium Severity Block Cracking

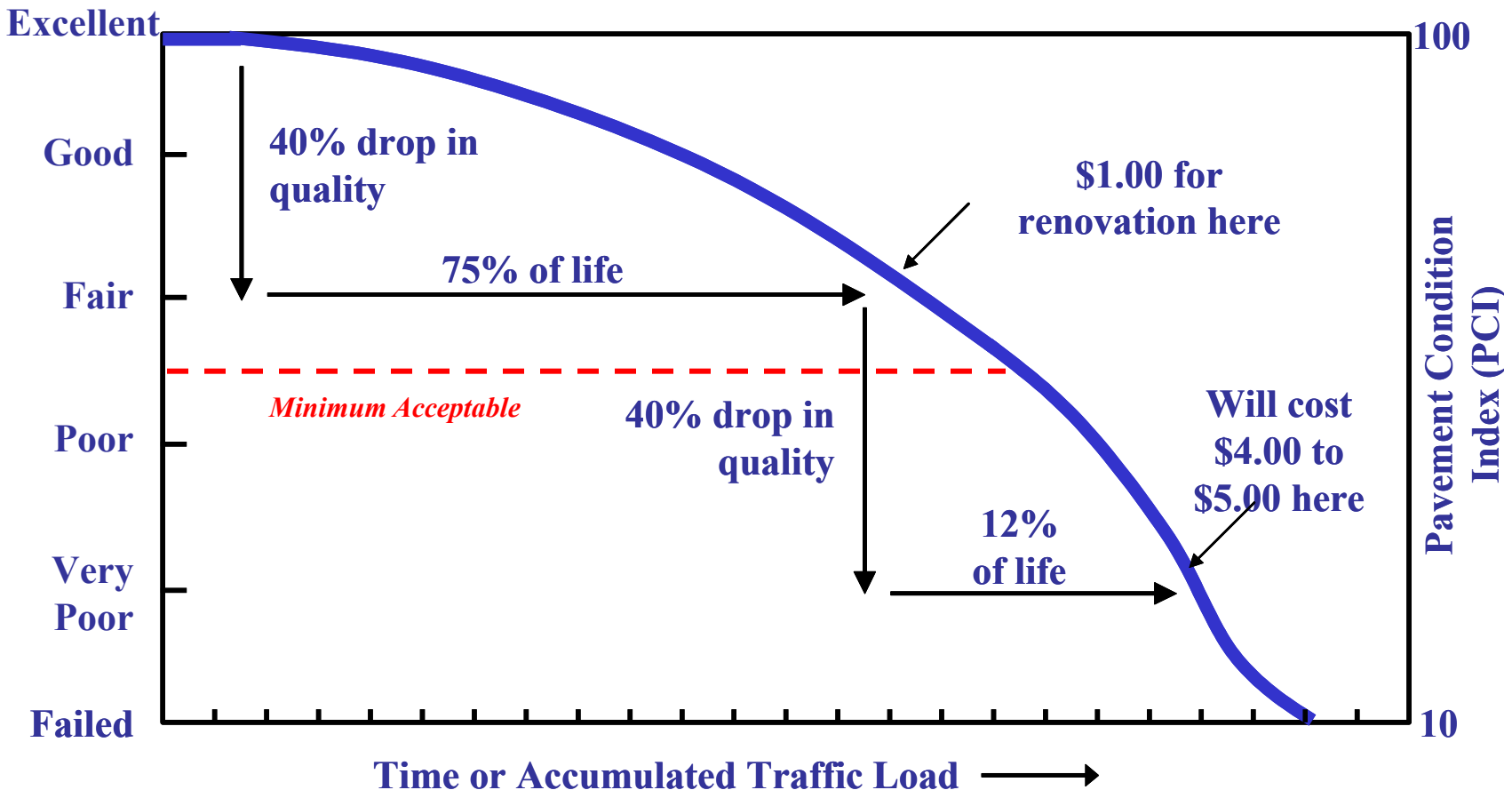
- 31.5% rural and 51.8% urban Interstate mileage rated in fair-to-poor condition
- Increased financial demands and down-sizing of public agencies
- Highway users-our customers identified improved “pavement conditions” and reduction of traffic delay as top priorities
- Good PMS implementation can help to improve the situation.

PAVER Pavement Condition Index (PCI)

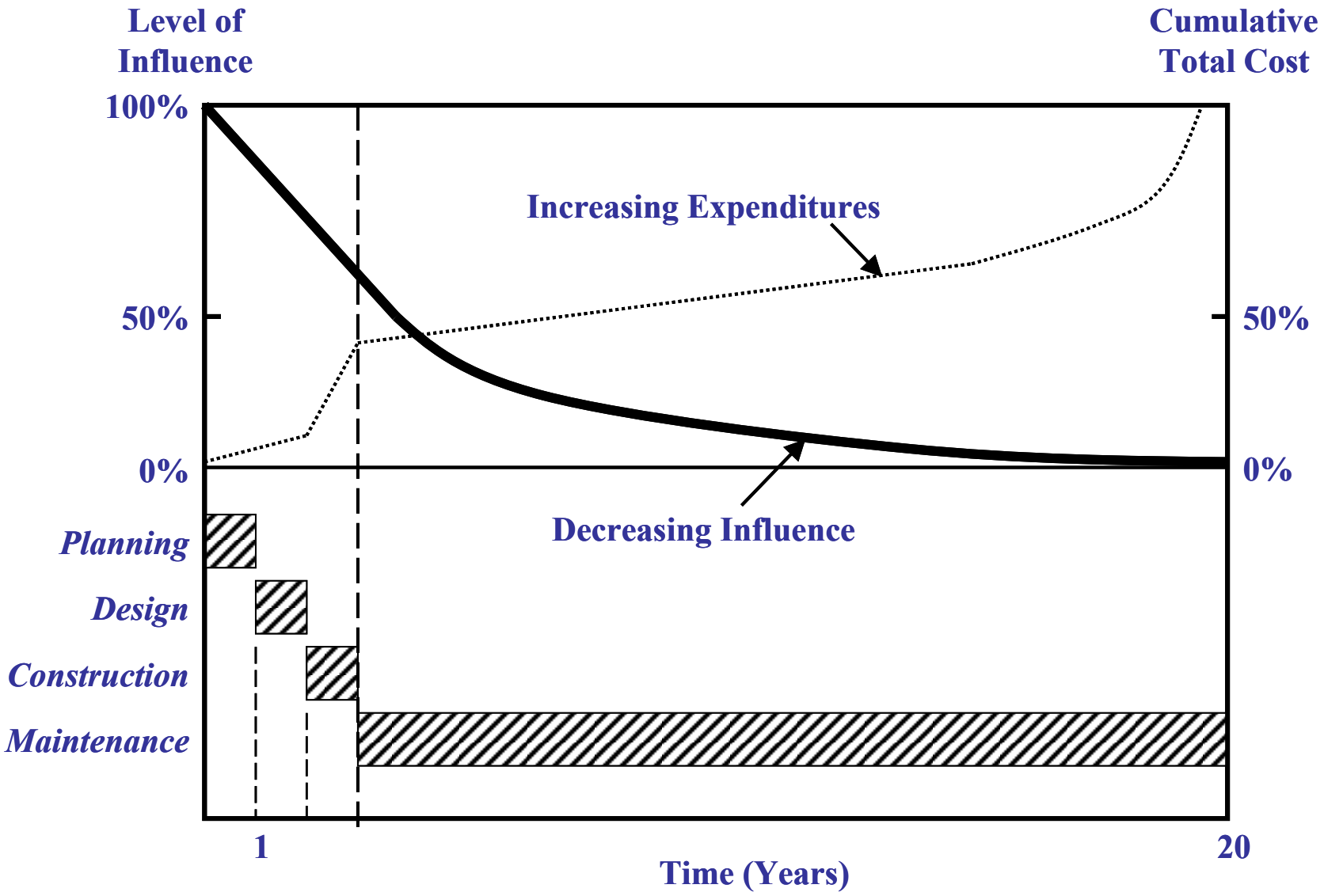


Maintenance, Rehabilitation & Reconstruction (M,R&R)

Timely M,R&R treatment saves $

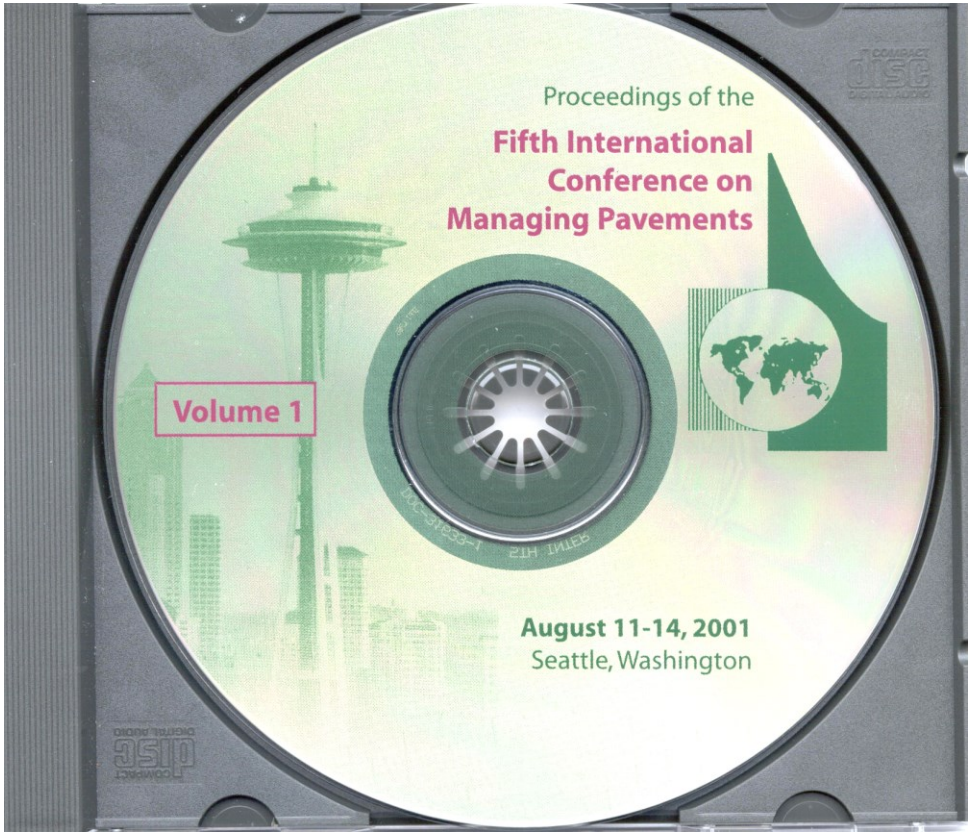


Influence Levels of PMS Subsystems on Total Costs [Haas 94]



key Milestones Pavement Management System (PMS)

- AASHO Road Test - 1959-61
- NCHRP Project 1-10, 1968; 1970's (Design based on systems approach, project-level concept)
- Operating PMS, 1970's…
- International road performance studies, early 1070's and 1980's
- NCHRP Report 215, 1979 (network-level PMS)
- PMS Policy by FHWA-1989, AASHTO -1990
- International PMS conferences 1985, 1987, 1994, 1998, 2001, 2004



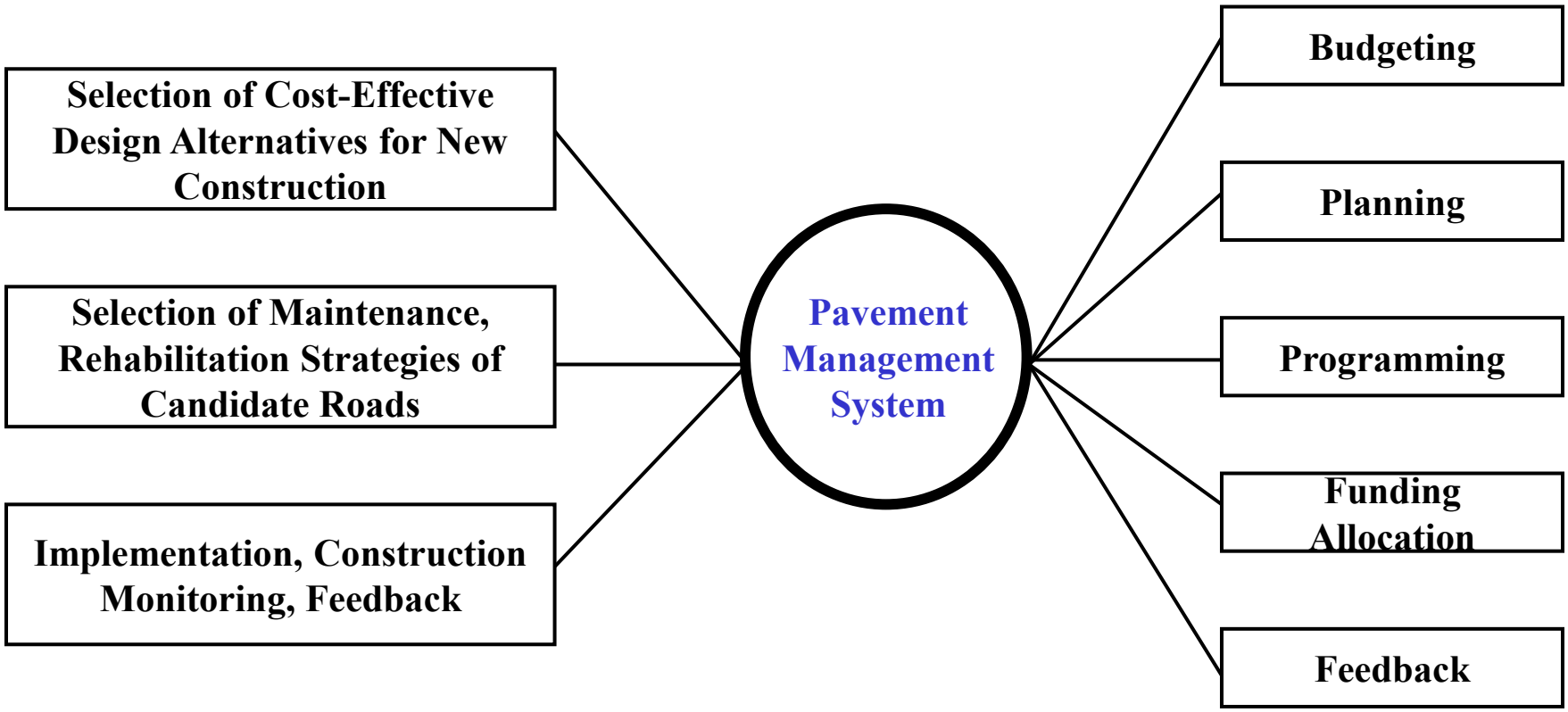
6th International Conference
19-24 October 2004
Brisbane, Queensland, Australia

PMS required on all federal-aid highway projects in the U.S., since 1991

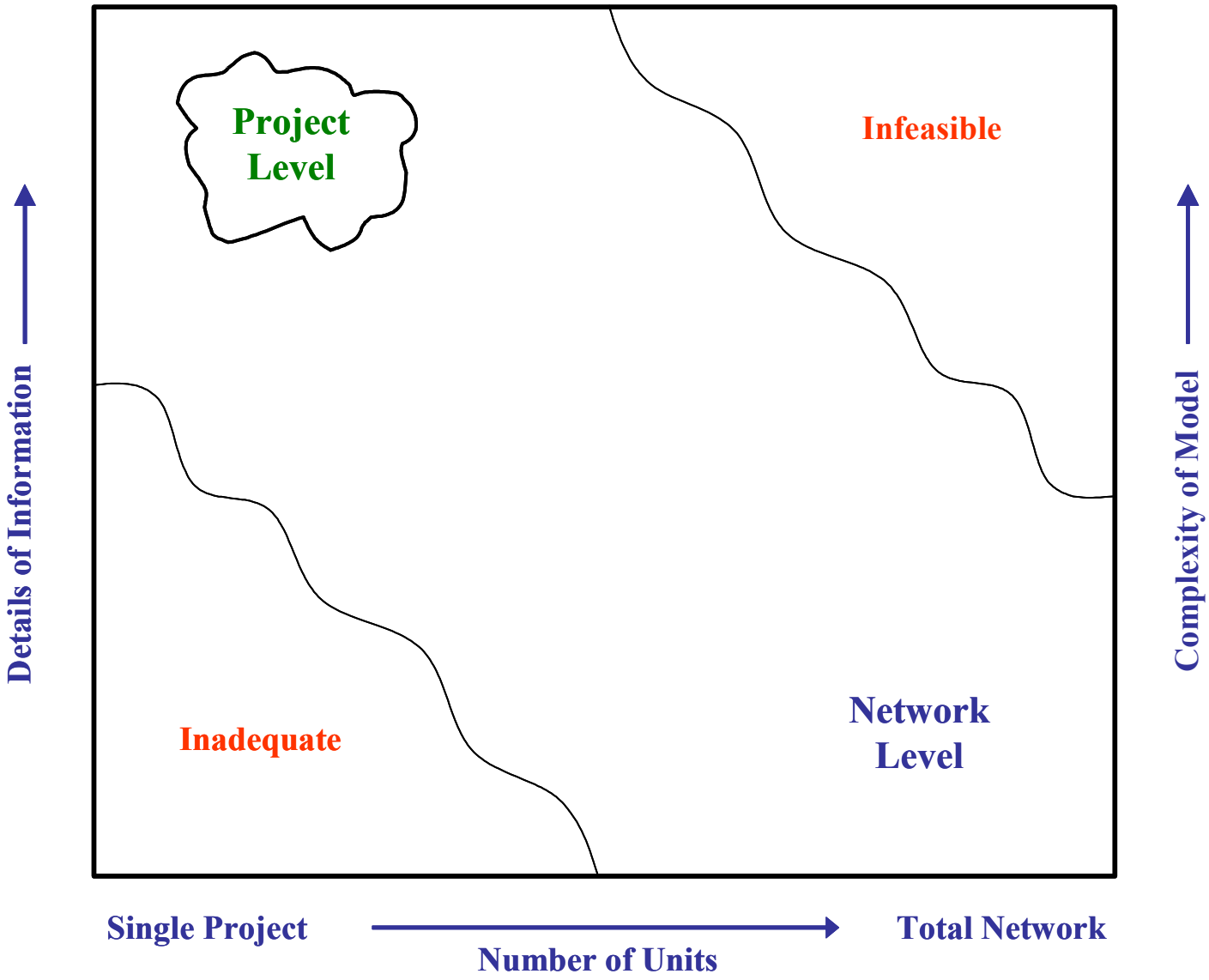
PMS Functions

Project Level PMS

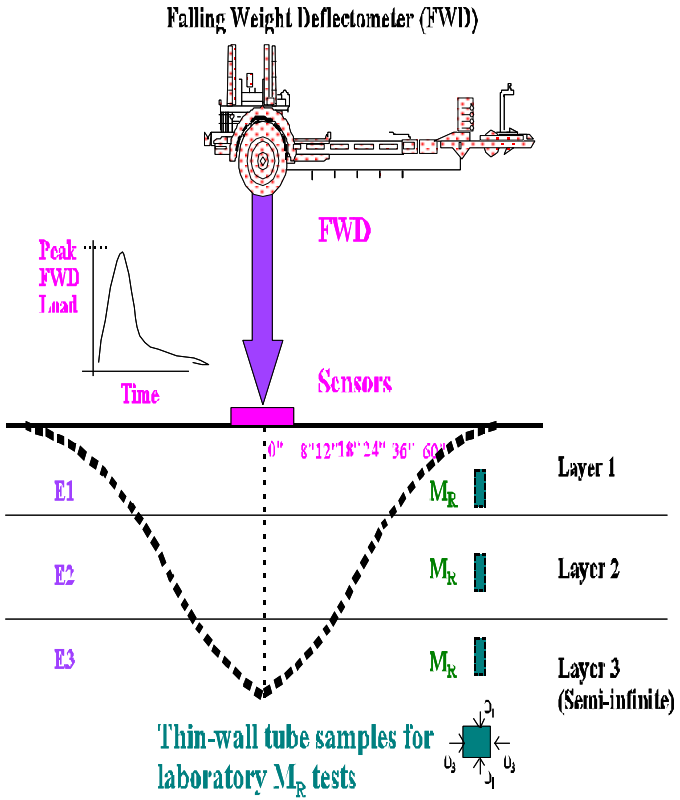
Network Level PMS



Pavement Management System Design Constraints -- DATA



Nondestructive Pavement Structural Evaluation by NDT Deflection Equipment

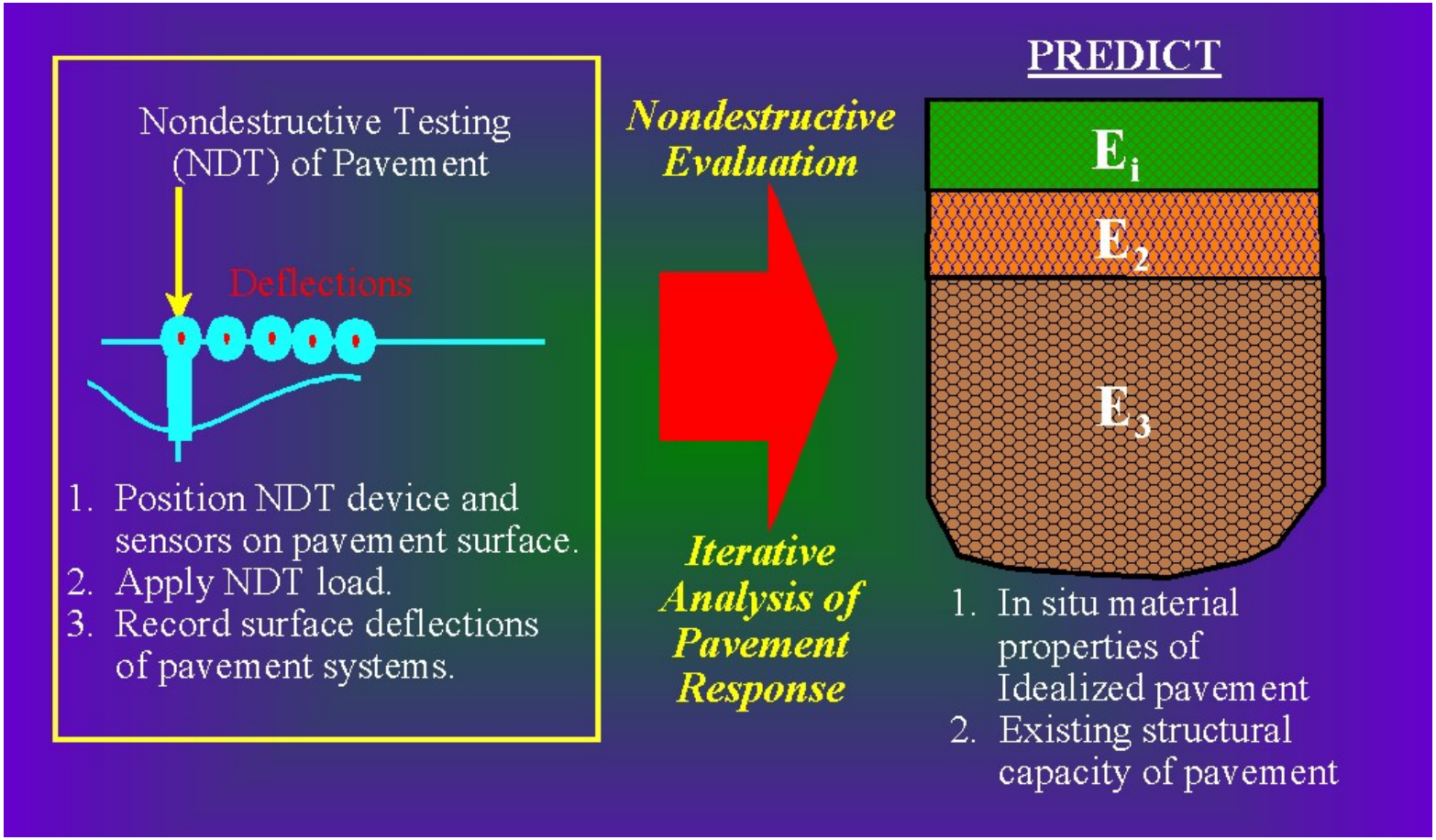


Project-Level PMS Example

Falling Weight Deflectometer (FWD)

Project-Level PMS Example

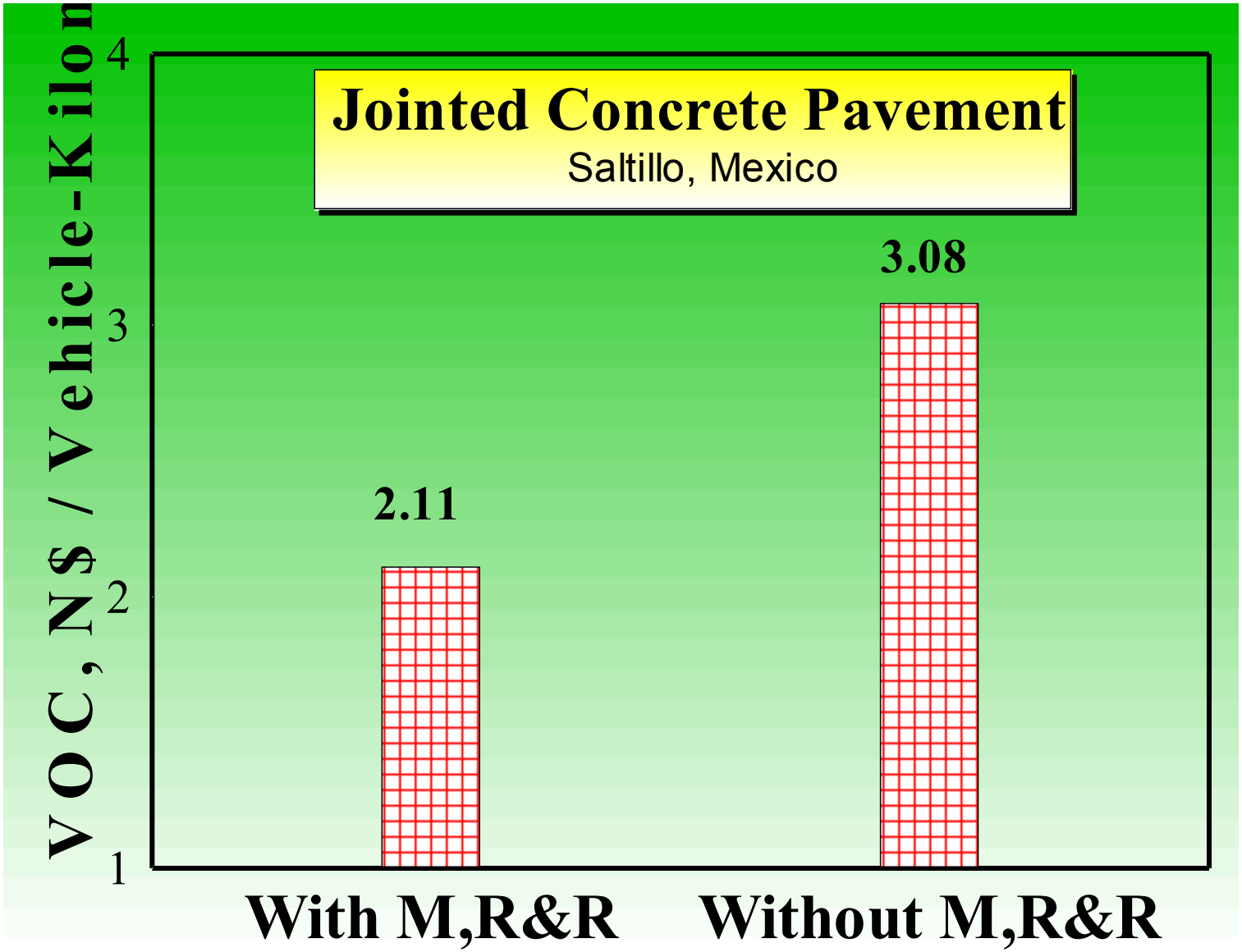
In Situ Modulus Backcalculation



Multilayered linear elastic theory is applied (self-iterative program).

- **Overlay thickness design taking into account: (a) structural load carrying capacity of existing pavement and (b) future traffic (ESALs applications)**

Life-Cycle Cost and Benefit analysis



PMS Development Costs and Benefits

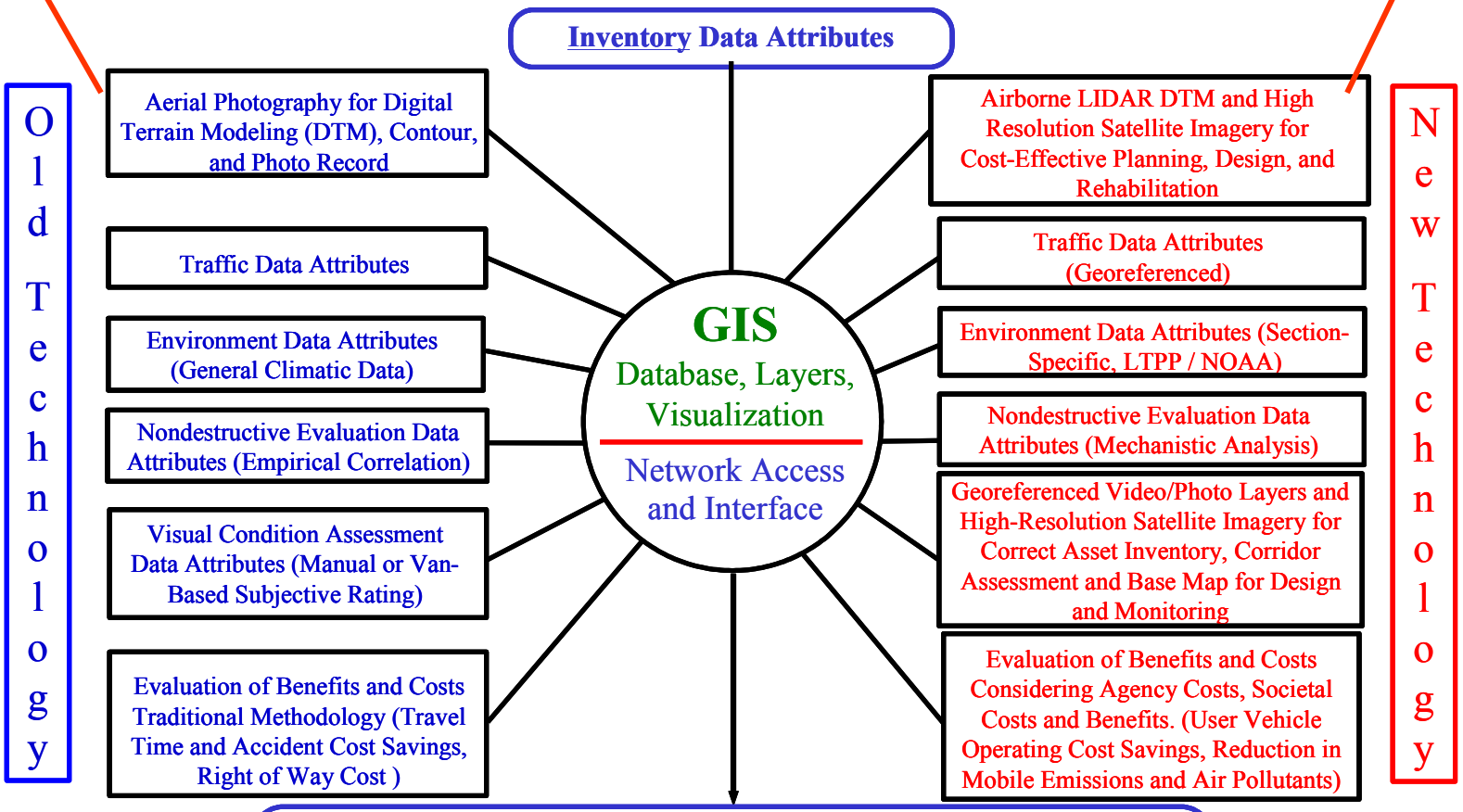
- **Most costs are related to development and implementation efforts, which include: staff, office facility and transport, pavement monitoring equipment and specialized pavement evaluation services, PMS analysis software and database system development and operation, and overall PMS operation and data collection (inventory, historical, environmental, traffic, construction and maintenance costs).**

- **Benefits of PMS development and operation are: improved pavement condition, cost-effective alternatives, effective use of funds, better M,R&R budgeting and planning, and benefits to the executive management with respect well informed decision-making information.**

Aerial Photography for Digital Terrain Modeling (DTM), Contour, and Photo Record

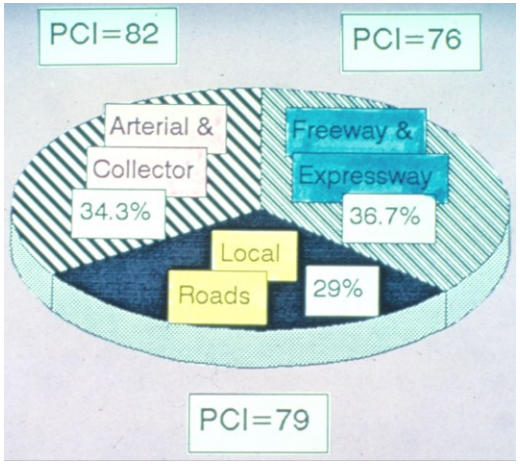
Airborne LIDAR and High Resolution Satellite Imagery for Cost-Effective Planning & Design

Transportation Corridor Inventory, Assessment, Planning, and Design; Benefit and Cost Evaluation



Planning, Design, Maintenance and Rehabilitation

Network-Level PMS Implementation Examples



1985-1989 Pavement Projects

Pennsylvania

Arizona

City of Albuquerque

SHRP-LTPP

Dubai Municipality, 1989-1993
UNCHS Project

Indonesia, Jasa Marga Toll Road Authority, 1991-1992
World Bank/Colin Corne Project

Mississippi Highway Department, 1991-1993

Mexico, Cities of Leon and Saltillo, 1993-1997

Brazil, Diadema City, Pavement Practices Review, 2006