Analysis of PMS Data for Engineering Applications

NHI Training Course No. 131105
Starting in 2003

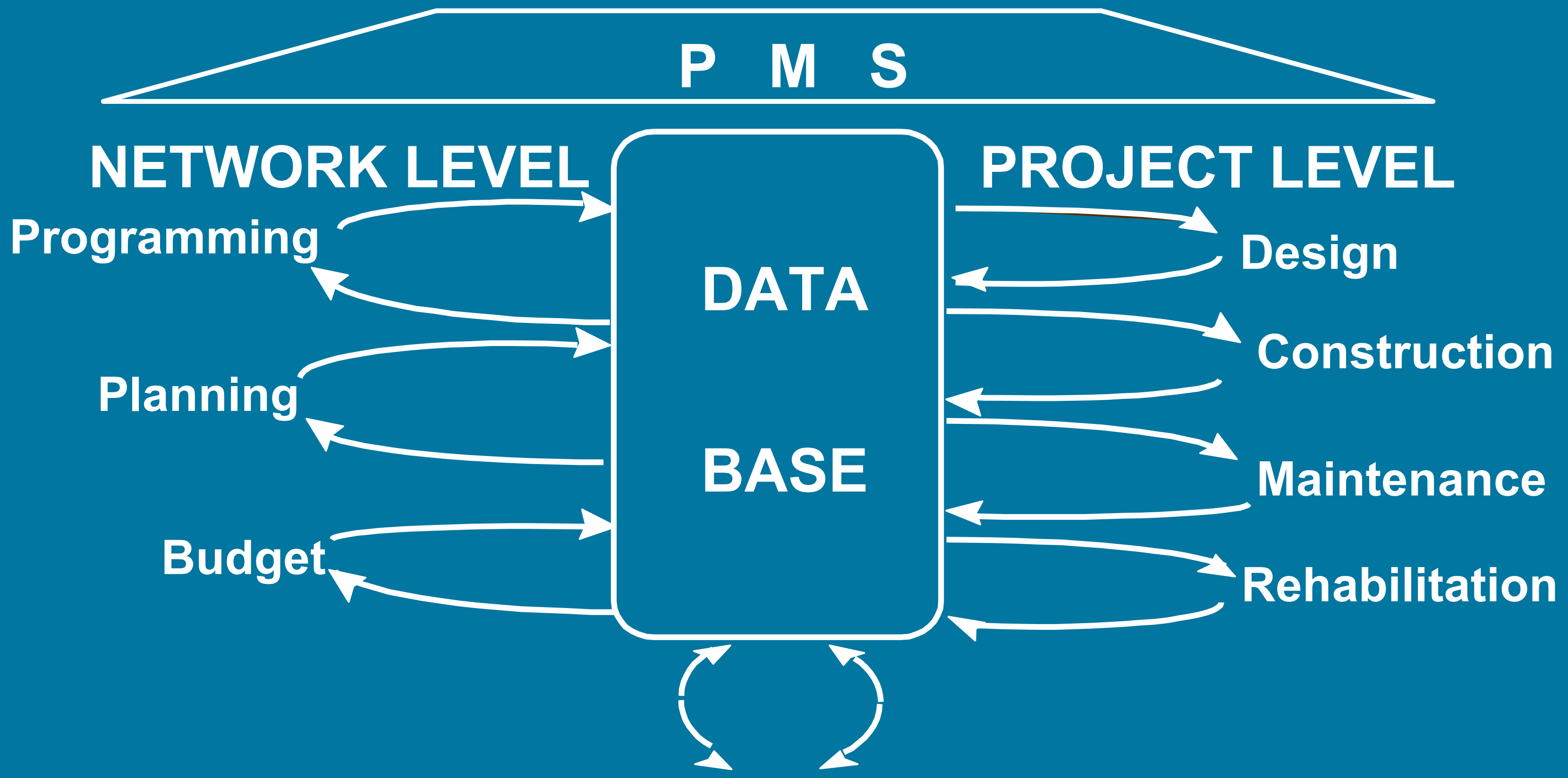
Engineering Application Examples from following State DOT's

- Arizona
- California
- Florida
- Georgia
- Kansas
- Maryland
- Michigan
- Montana
- Pennsylvania
- Texas
- Washington
- Wisconsin

Examples of Subjects Covered

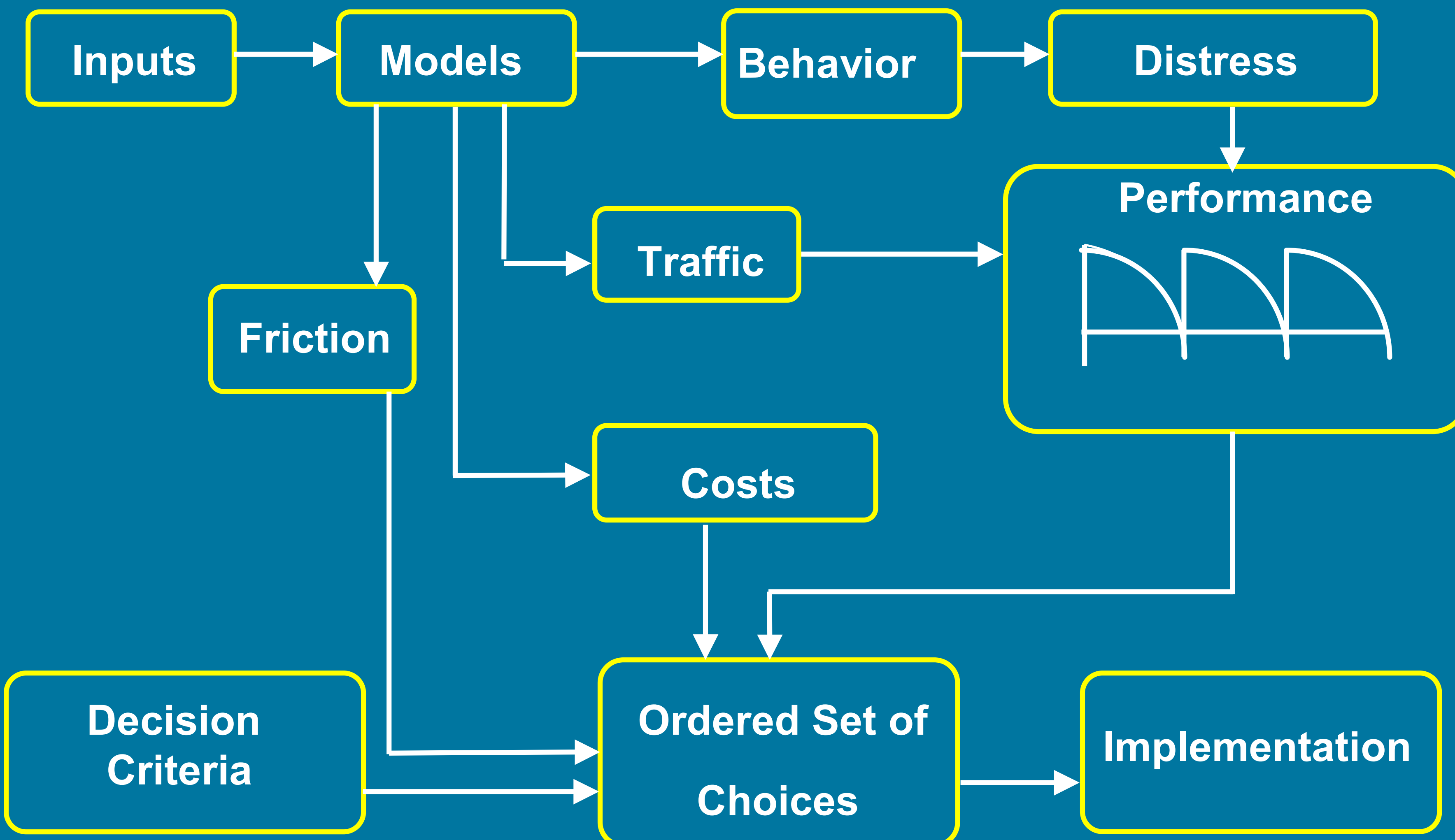
- Benefits of a Pavement Management System
- Using a PMS to monitor materials performance
- Modeling of pavement performance data
- Comparison of various of overlay design systems
- Use of PMS to solve problems with PCC pavements
- Optimize Preservation through LCCA of various alternatives
- Integrating maintenance activities in PMS

Components of PMS



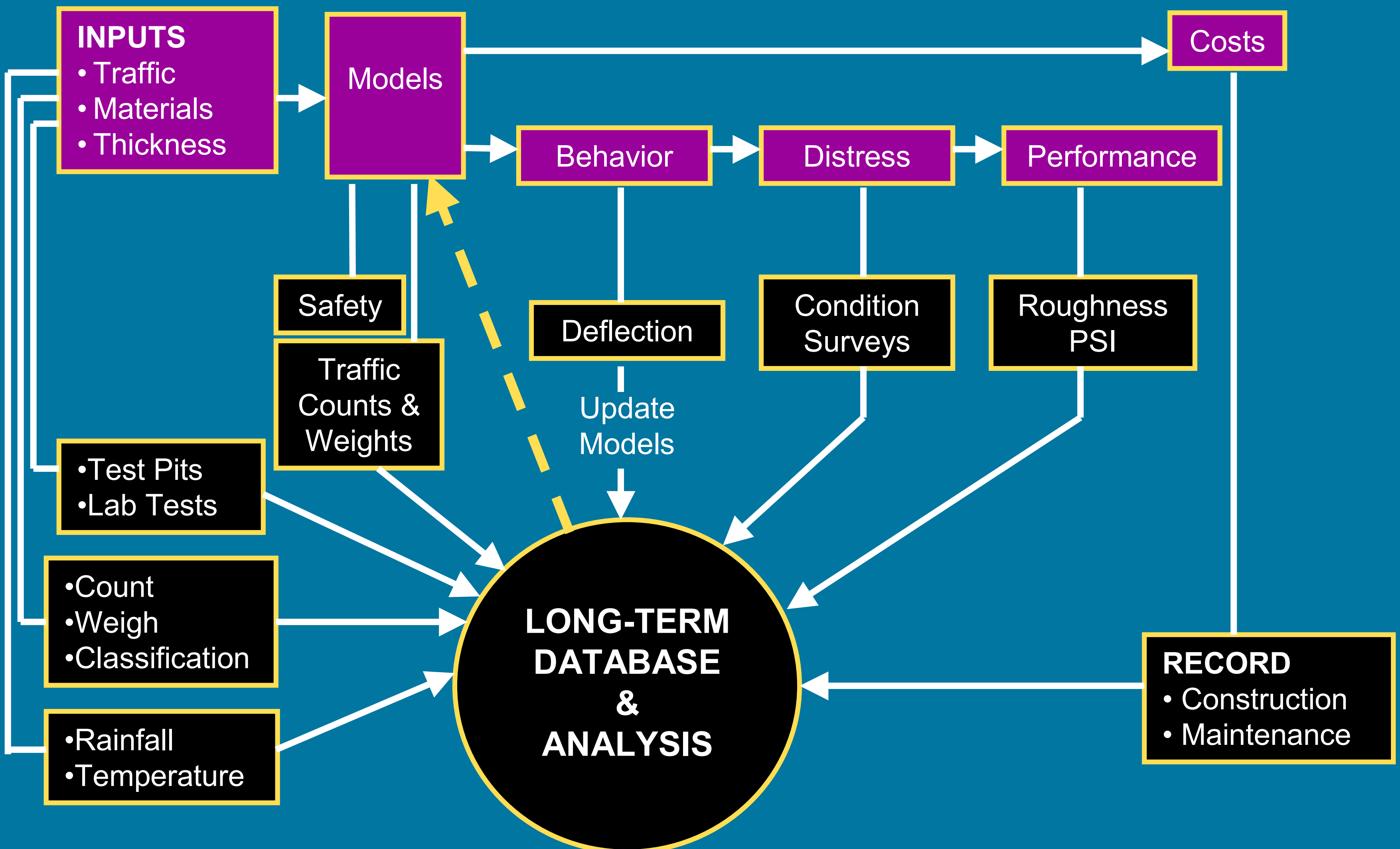
Engineering Applications
Research - Special Studies

Major Components of a Project Level Pavement Design System



A quote which properly defines a PMS database by Aaron J. Ihde:

"The primary factor in bringing about scientific discovery is not necessity or individual genius, but the relentless pressure of accumulating knowledge".


INPUTS
• Traffic
• Materials
• Thickness
Models
Costs
Behavior
Distress
Performance
Safety
Traffic Counts & Weights
Deflection
Condition Surveys
Roughness PSI
Update Models
•Test Pits
•Lab Tests
•Count
•Weigh
•Classification
•Rainfall
•Temperature
LONG-TERM DATABASE & ANALYSIS
RECORD
• Construction
• Maintenance

Summary of PMS

- Network and project level
- Several major subsystems
- Performance database for model development
- Proper information flows
- Pavement evaluation

Engineering Analysis Essential part of PMS

- Pavements are engineered structures, therefore engineering analysis:
  - Improves pavement performance
  - Can be used for network or individual problems
  - Is essential for feedback purposes
  - Affects future activities - design, construction maintenance, standards, and specifications
- Involves both project & network level data

Purpose of PMS Engineering Analysis

The use of pavement management data to evaluate and improve structural designs (e.g. AASHTO 2002), materials, mix designs, construction, preservation strategies, rehabilitation, and preventive maintenance of pavements.

But: PMS does not have all needed data!

Sources of Engineering Data other than from PMS database

- Research data files
- Construction records
- Material test records
- Additional field evaluations
- Project plans
- Additional structural evaluation and/or materials testing
- Expert opinion and forensics
- Maintenance Management Systems

Quantified Benefits of a PMS

- Study for Arizona DOT in 1998 by TRDI
- ADOT's PMS was initiated in 1980
- Need to evaluate impact of PMS on:
  - pavement performance
  - pavement life
  - selection of materials
- Use of PMS database to quantify effects

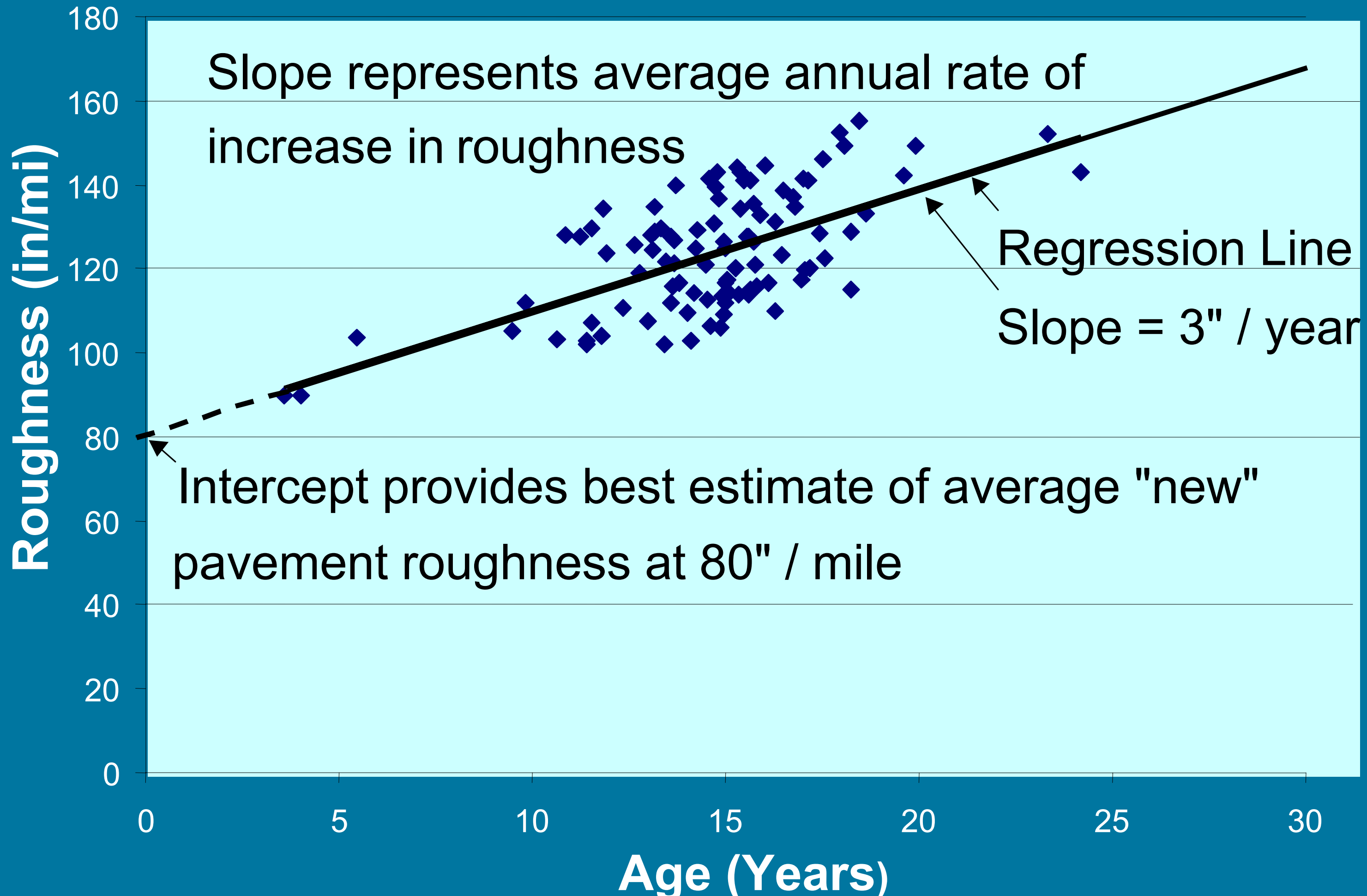
Creating The Database

- Historical Roughness data
  split as follows:
  - Data that reflect **Pre-PMS** experience from years 1981 - 1983
  - Data that reflect **Full-PMS** experience from years 1993 - 1995. (For later years project files not complete).
- Data evaluated in Visual Modeler.
- Each period contains about 20,000 records.

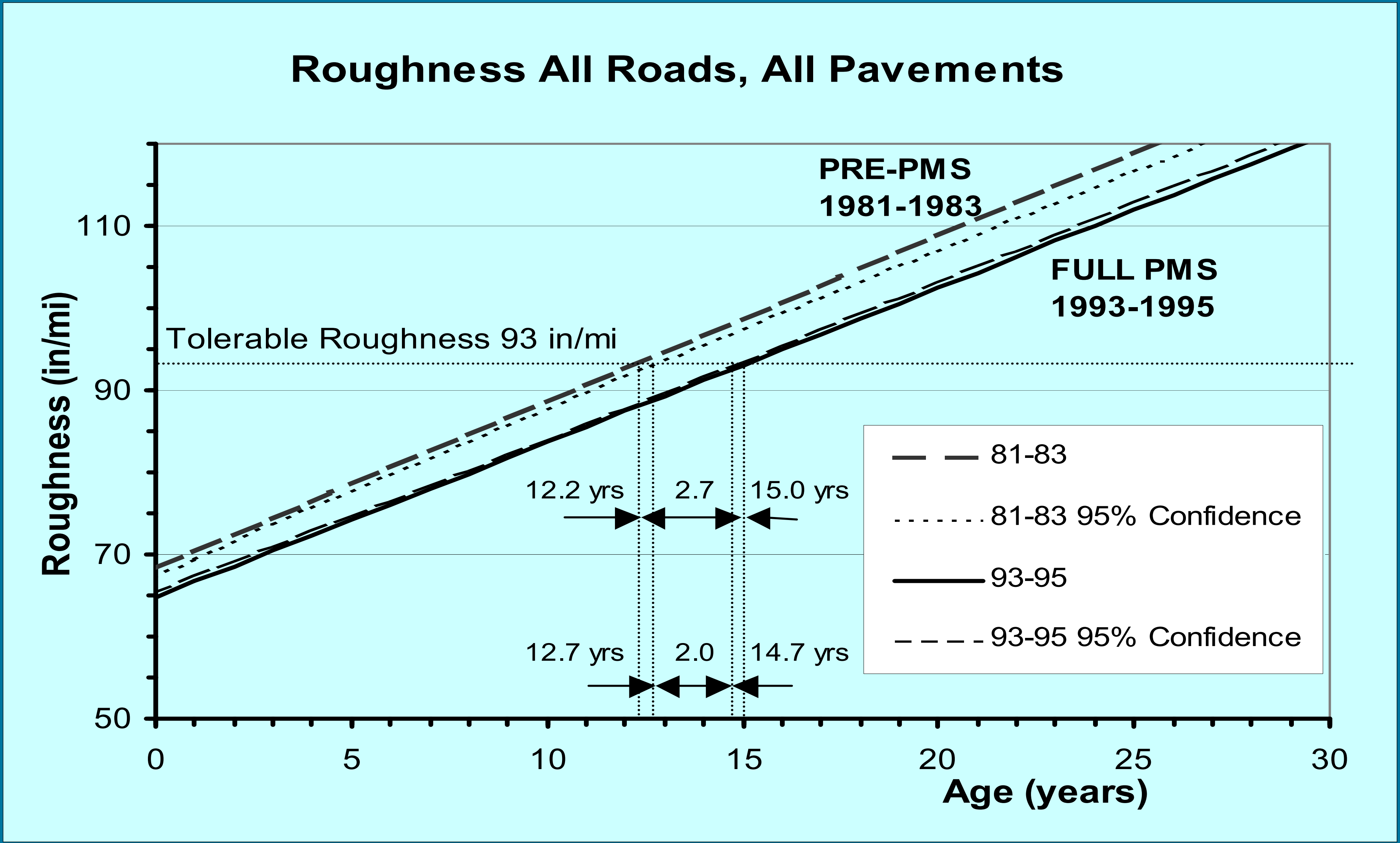
Results

- Roughness by far the best indicator of performance and shows the best correlation for data set.
- Cracking shows stable relationships, but not as robust as for roughness

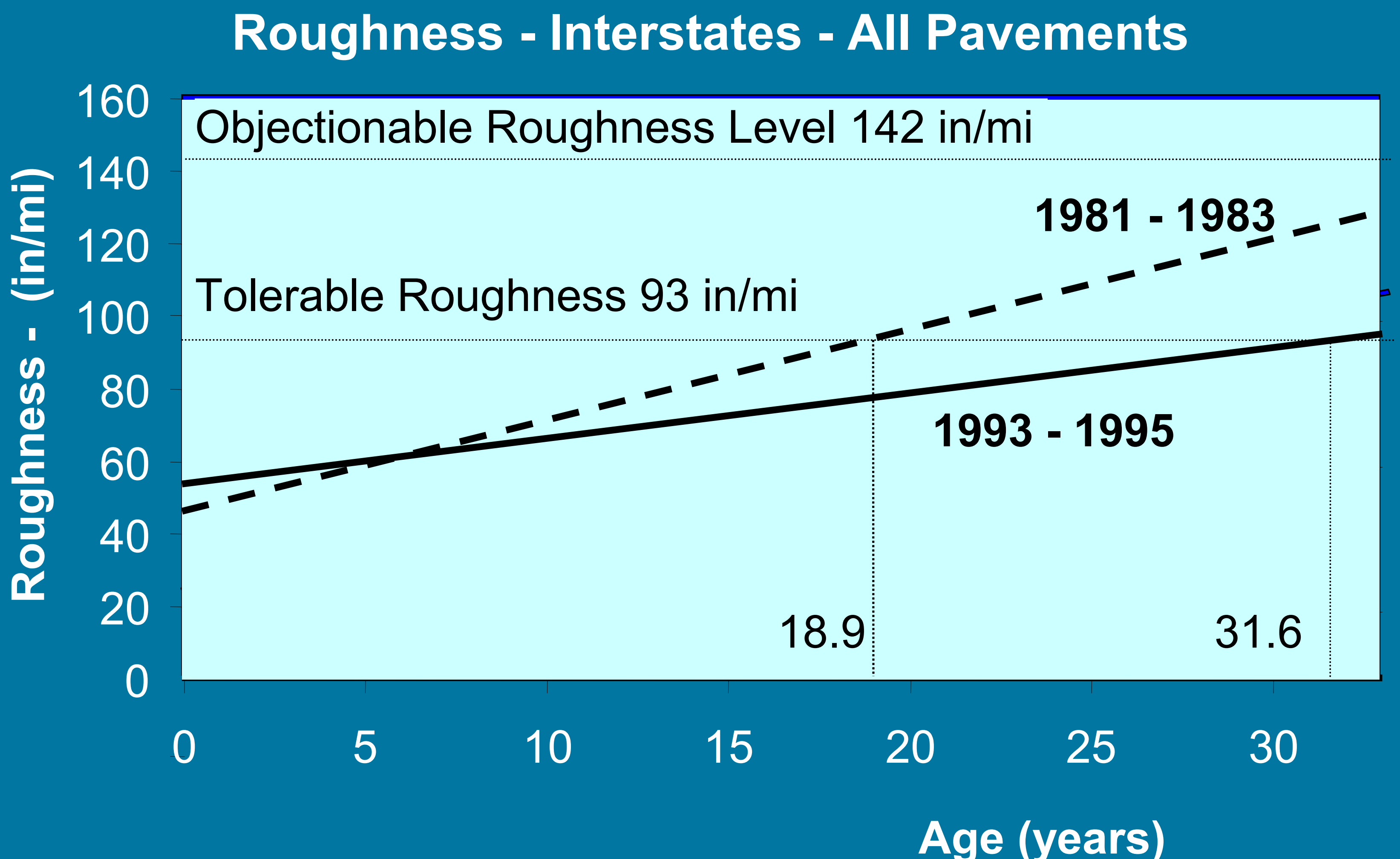
Quantify With Visual Modeler



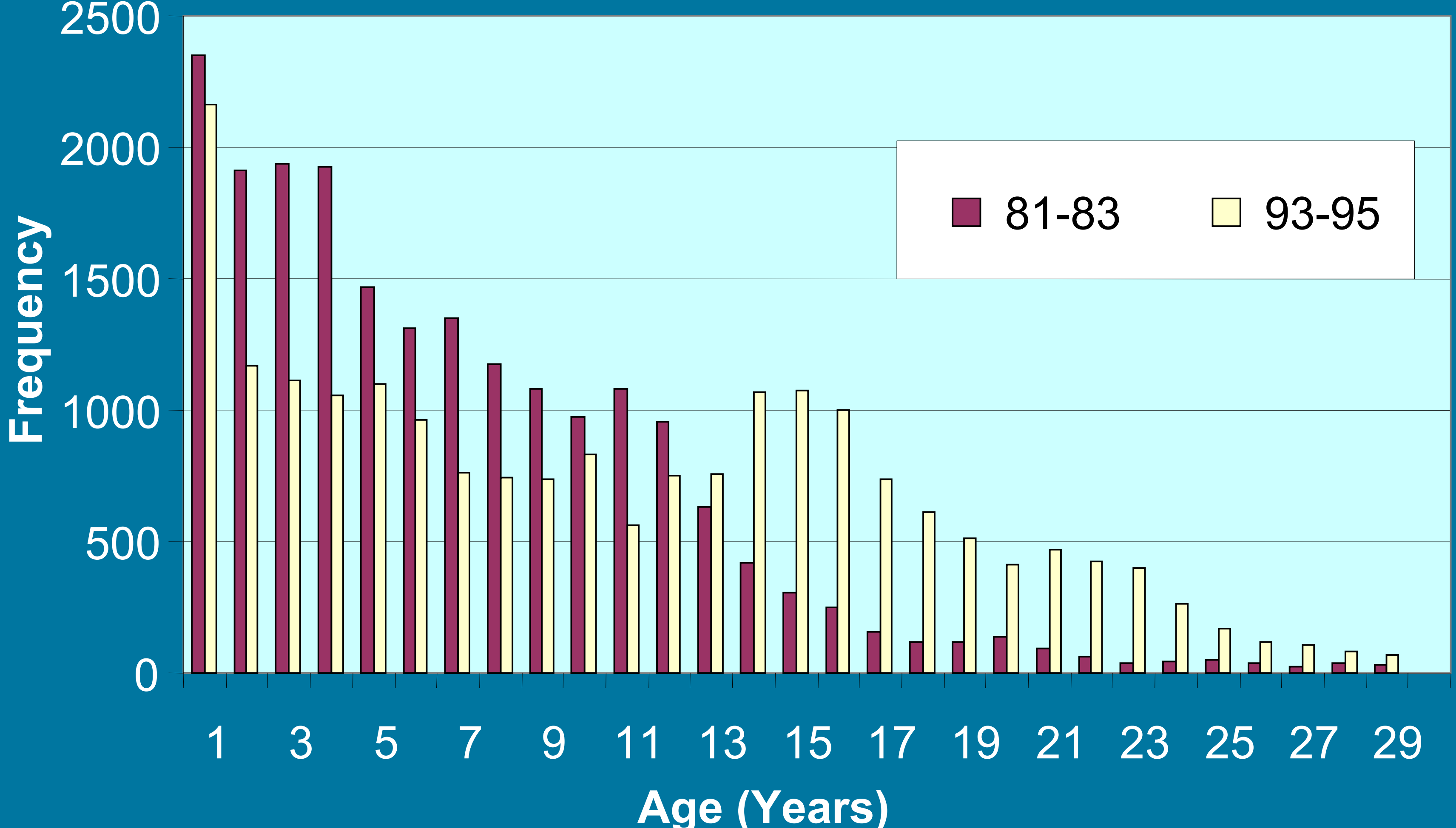
PMS Results in Longer Life



Example for Interstates only



Age Distribution
All Roads, All Pavements



Quantification of Benefits

- Improved Pavements with longer life:
- Total Budget for yrs 81-96: $3,135 million
- Average increase in life 2.0 yrs or 13.5%
- Minimum increase in life 1.3 yrs or 8.6%
- Average corresponding benefit over 16 years of $423 with minimum of $270 million at 95% confidence.

ADOT Total PMS Costs

	1981	1996
DEVELOPMENT	44,000	44,000
OPERATING	430,000	525,000
TOTAL	474,000	569,000

TOTAL FOR 16 YEARS = $8,340,000

ADOT's PMS Total Benefits/Costs

Total PMS costs $8.3 Million over 16 yrs.
Benefits at minimum confidence level $270 Million, at average level $423 Million.

Minimum at 8.6% increase in life:

$$\text{Benefit/Cost Ratio} = \frac{\$270 \text{ Million}}{\$8.3 \text{ Million}} = 33 \text{ to } 1$$

Average at 13.5% increase in life

$$\text{Benefit/Cost Ratio} = \frac{\$423 \text{ Million}}{\$8.3 \text{ Million}} = 51 \text{ to } 1$$

Total Benefits/Costs Sensitivity Including User Costs

- Assume minimum benefits (95%) of $270 million with 33:1 benefit cost ratio (BCR)
- World Bank: User benefits are 4 - 10 x cost of road expenditures,
- Benefits to Arizona citizens over 16 yrs would be at least $ 1 billion, with BCR of more than 100:1

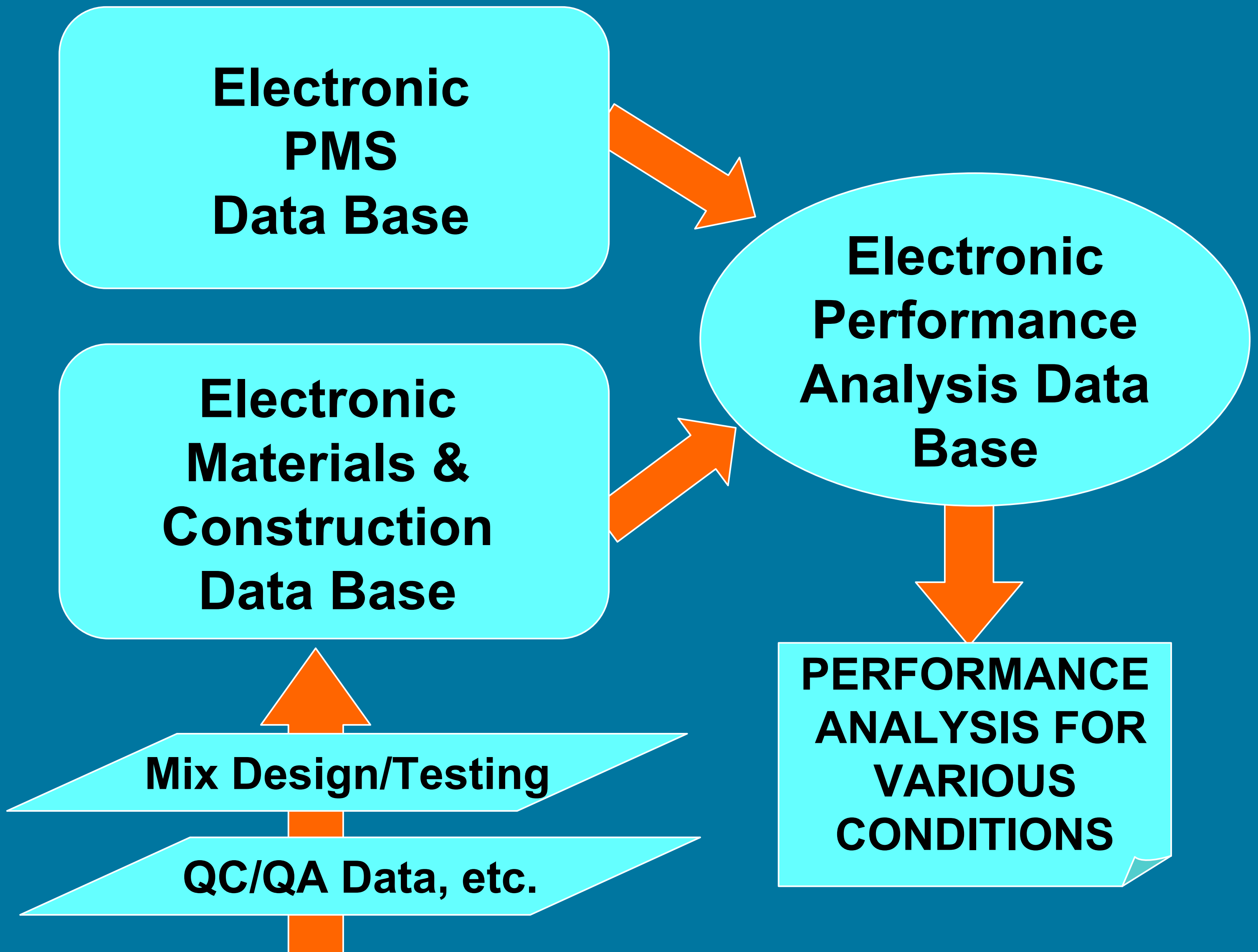
Summary of PMS Benefits

- Many “general” benefits, such as improved communications, better decision taking, asset management, etc are present in PMS but difficult to quantify.
- With well maintained comprehensive database, benefits can indeed be defined in number of ways, and reliably quantified.
- As shown in Arizona, they are sizeable.

Using PMS Data to Monitor Performance of Superpave

- Study for FHWA by TRDI with:
  - Ronald Hudson,
  - Charles Dougan,
  - Carl Monismith,
  - Pim Visser
- DOT's of Maryland, Indiana, Florida, Arizona and Washington have been visited,
- Superpave used as test case - outcome of study equally valid for other materials and/or construction techniques & concepts.

Concept for Linking Databases



Electronic PMS Database

- **Common referencing is needed with Project Number, exact Location and Date**
- Climate and Traffic (ESAL and ADT) Data,
- Age of original pavement and last rehab date,
- Details of existing pavement structure,
- Performance Data for various distresses should be linked to exact location (mile post or GPS, Lane and Direction).

Electronic Materials and Construction Database

- **Common referencing is needed with Project Number, exact Location and Date**
- Mix data, as designed and in-place
- Layer thickness, designed and actual
- Other materials information & construction details
- Effects of maintenance activities
- Batch/lot numbers should be linked to location.

Electronic Performance Analysis Database - Created by Linking

- **Common referencing is needed with Project Number, exact Location and Date**
- Essential materials and construction data linked to performance data through common referencing
- Possible to study effects on performance of materials, construction techniques, traffic loads, climate, thickness design (AASHTO 2002), etc.

NETWORK ANALYSIS

1. Assemble Database for adequate number of sections,
2. The more sections the better - large sample statistics very powerful,
3. Several States can combine Data with good coordination at the national level,
4. Effects of all variables present in the Database can be evaluated and analyzed,
5. Early implementation provides impetus to enter data early – No “build-up” of backlog.

PROJECT ANALYSIS

- Assemble Database for adequate number of lots,
- The more lots the better - large sample statistics very powerful (lots across projects with similar characteristics can combine data),
- Effects of all variables present in the database can be evaluated and analyzed, such as:
  - Effects of scatter in material properties,
  - Susceptibility of materials or techniques to adverse conditions,
  - Assessing best compaction techniques for certain materials, etc.

Current Limitations (1of 2)

- In most cases the materials, construction, and maintenance data are not now tied to PMS activities.
- Most agencies store materials and construction data in flat files, so transfer and analysis of data is hard to do.
- Not all relevant data are recorded (e.g. in-place thickness is often missing).
- Linking materials and construction data to an exact location is difficult or impossible.

Current Limitations (2 of 2)

- Performance data are often averaged over a mile. Distress is often sampled over short distances, e.g. milepost only. Normally only one lane is measured.
- Therefore, difficult to link performance data to materials and construction data.
- Maintenance activities, if not properly recorded and referenced, could distort the analysis.
- DOTs need time to plan organizational structures to implement the new approach.

PHASE 2: PATHFINDER STUDY

- Maryland SHA agreed to provide PMS, materials and construction data in electronic format,
  - Sam Miller, Larry Michael, Pete Stephanos, Paul Dorsey, Gloria Burke, and others.
- The University of Washington offered to put the MD data in their newly developed web based evaluation system,
  - Joe Mahoney, George White.
- TRDI coordinated.

PROPOSED DATA FIELDS

QC/QA Data	Mix Design Data
28 fields: Electronic: 8 Paper: 16 Not available: 4	16 fields: Electronic: 9 Paper: 6 Not available: 1
Pavement Design Data	**PMS Data**
11 fields: Electronic: 0 Paper: 10 Not available: 1	16 fields: Electronic: 9 Paper: 4 Not available: 3

EVALUATIONS AT NETWORK LEVEL

- Binder content vs rutting,
- Fines (passing P200) vs rutting,
- IRI of several projects by year,
- Rutting of several projects by year,
- IRI vs use of Material Transfer Vehicle,
- IRI vs night/day paving,
- IRI vs surface preparation.

EVALUATIONS AT PROJECT LEVEL

- IRI by year,
- Rutting by year,
- IRI vs distance/lots,
- Rutting vs distance/lots,
- IRI vs use of Material Transfer Vehicle,
- IRI vs night/day paving,
- IRI vs surface preparation.

LIMITATIONS OF DEMO

- Only seven projects,
- Only 1 or 2 years of performance data,
- No data or not enough data for:
  - Cracking
  - Mix temperatures
  - Rolling patterns
  - MTV use
  - Lot locations
- Consequently demo should be judged on the potential capabilities of the system, not these interim results.