U.S. Department of Transportation
Federal Highway Administration

The Long Term Pavement Performance Program

North Central Asphalt User/Producer Group

Jan 28, 2004 Omaha NE

LTPP Development

1984	➢ Strategic Transportation Research Study
1985-1987	➢ LTPP Planning
1987-1992	➢ Strategic Highway Research Program (LTPP: $50 Million component of SHRP)
1992 -2009	➢ FHWA – LTPP Data Collection and Data Analysis

WHAT IS LTPP & IT's OBJECTIVE?

- Monitor Sites across the North American Continent --> Research DATABASE
- Understanding "why" some pavements perform better than others: Lead to Better Performing and More Cost Effective Pavements.

General Pavement Studies (GPS)

GPS-1 → Asphalt Concrete (AC) on Granular Base

GPS-2 → AC on Bound Base

GPS-3 → Jointed Plain Concrete Pavement

GPS-4 → Jointed Reinforced Concrete Pavement

GPS-5 → Continuously Reinforced Concrete Pavement

GPS-6A→ Existing AC Overlay on AC Pavements

GPS-6B→ New AC Overlay on AC Pavements

GPS-7A→ Existing AC Overlay on Portland Cement Concrete (PCC) Pavements

GPS-7B→ New AC Overlay on PCC Pavements

GPS-9 → Unbounded PCC Overlays on PCC Pavements

General Pavement Studies (GPS)

- Focus on most commonly used pavement designs
- Experimental design: full factorial
- One 500 foot section per location

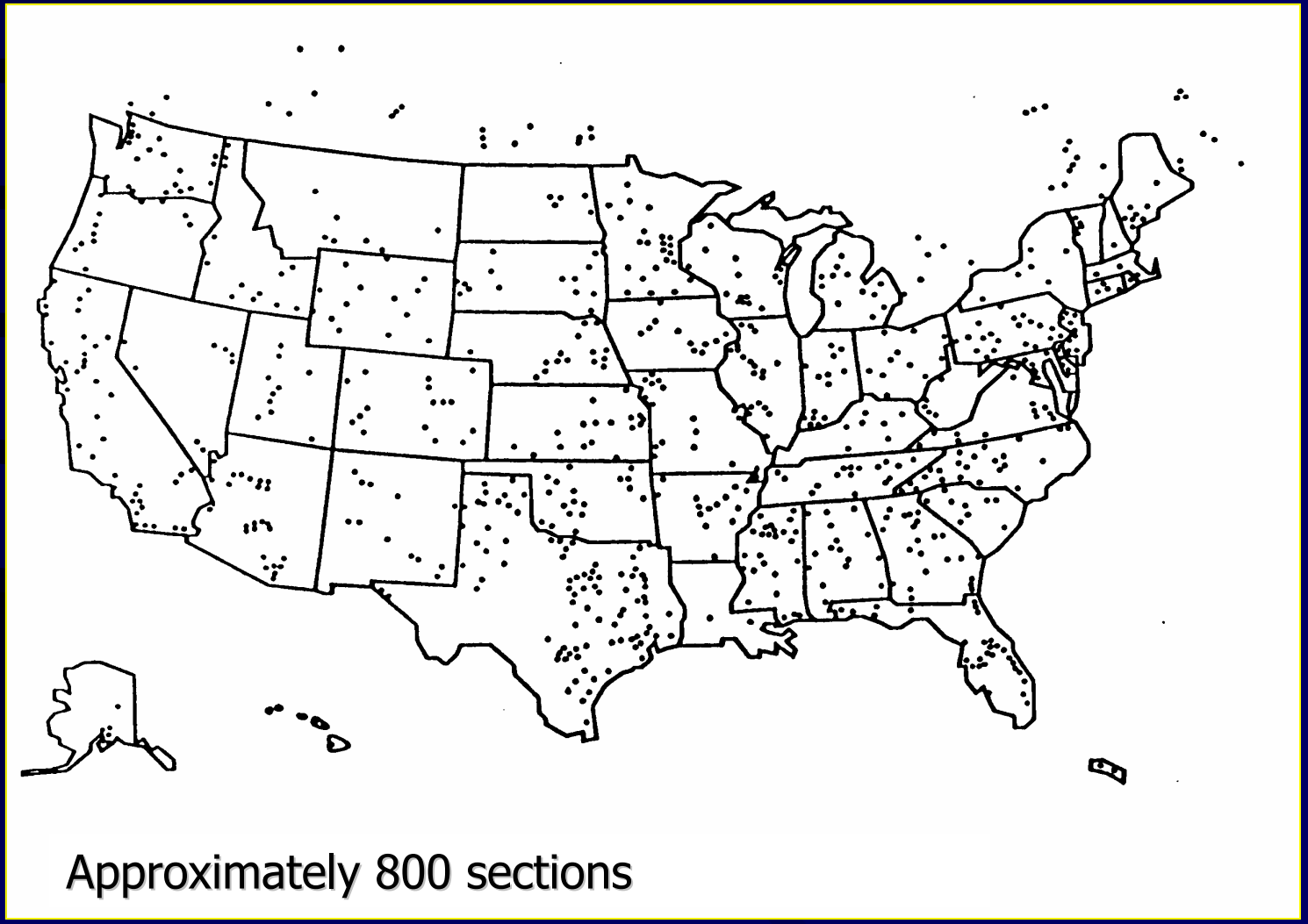
Primary Factors

Subgrade: fine & course
Traffic: medium & heavy
Temp: freeze and non-freeze
Moistures: wet and dry

Secondary Factors

AC thickness
AC stiffness
SN of base and subgrade
PCC thickness
Joint spacing

General Pavement Studies (GPS)



Approximately 800 sections

Specific Pavement Studies (SPS)

SPS-1 → Strategic Study of Structural Factors for Flexible Pavements

SPS-2 → Strategic Study of Structural Factors for Rigid Pavements

SPS-3 → Preventative Maintenance Effective for Flexible Pavements

SPS-4 → Preventative Maintenance Effective for Rigid Pavements

SPS-5 → Rehabilitation of AC Pavements

SPS-6 → Rehabilitation of Jointed PCC Pavements

SPS-7 → Bonded PCC Overlays on Concrete Pavements

SPS-8 → Study of Environmental Effects in the Absence of Heavy Loads

SPS-9 → Validation of SHRP Asphalt Specification and Mix Design (Superpave)

Specific Pavement Studies (SPS)

- Focus on certain pavement engineering factors
- Experimental design: half factorial
- Multiple 500 feet sections per location

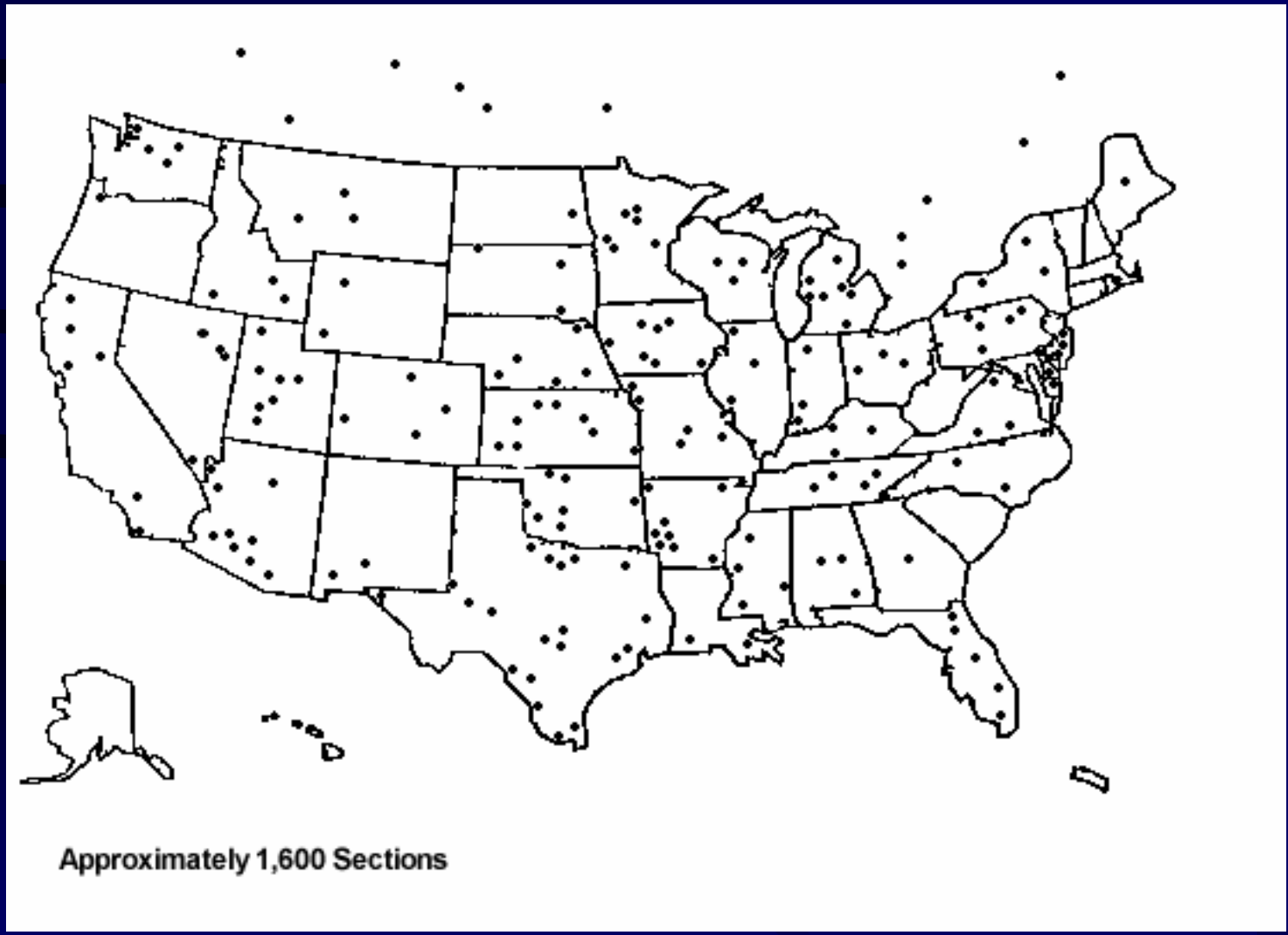
Primary Factors

Subgrade: fine & course
Traffic: medium & heavy
Temp: freeze and non-freeze
Moistures: wet and dry

Secondary Factors

AC drainage - yes, no
AC thickness
AC base type and thickness
PCCP drainage- yes, no
PCC strength and thickness
Lane width
Base type

Specific Pavement Studies (SPS)



LTPP's GOAL

To provide answers to

HOW and **WHY**

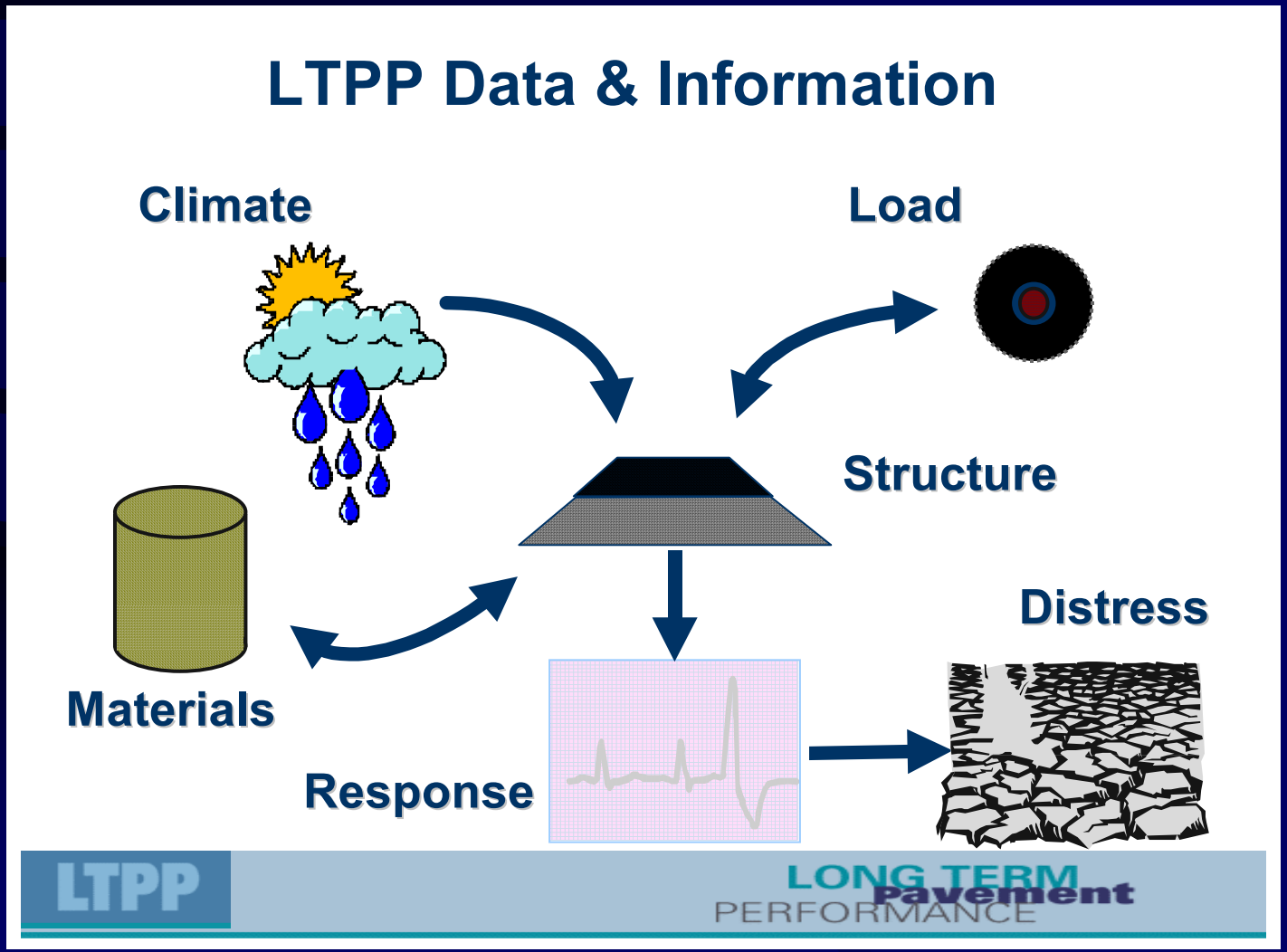
pavements perform as they do!

LTPP's CORE FUNCTIONS

1. **Data Collection and Management**

➔ Collect, Process, Store and Provide Readily Accessible, Quality Data

LTPP Data Collection



FWD Data Collection

Profile Data Collection

Distress Data Collection

Materials Sampling

Materials Test Data Collection

- AC Layer - thickness and properties
  - Resilient Modulus
  - Specific Gravity
  - Asphalt Content
- PCC Layer - thickness and properties
  - Compressive and Splitting Tensile Strength
  - Coefficient of Thermal Expansion
  - Static Elastic Modulus
- Unbound Layers - thickness & properties
  - Resilient Modulus
  - Classification and Sieve Analysis
  - Moisture/Density Relations

Materials Properties Testing

Weather Station Data

Seasonal Variation Data Collection

Forensic/Diagnostic Investigations

Traffic Data - WIM & AVC

- Vehicle Weight Data and Vehicle Classification

LTPP Data & Information:

- Pavement Performance Database
- Central Traffic Database
- Ancillary Data

LTPP Database

MODULES
(12 Modules)
- Climatic
- General
- Inventory
- Maintenance
- Monitoring
- Rehabilitation
- SMP
- SPS (10)
- Traffic
- etc

TABLES
(516 Tables)
- Deflection
- Profile
- Friction
- Distress
- Materials
- etc

ELEMENTS
(12,844 elements)
- Date
- Time
- Temperature
- Properties
- Individual data elements

- **> 30 gigabytes of data in the Database**
- **> 40 gigabytes of data off-line**

LTPP Pavement Performance Database: Release History

- Release 1, January 1991 ⇨ < 300 records
- Release 2, July 1991 ⇨ ~ 2K records
- Release 3, January 1992 ⇨ ~ 8K records
- Release 14, July 2002 ⇨ ~ 125M records
- Release 17, January 2004 ⇨ ~ 135M records

Some Database Statistics (August 2003)

- > 7,000,000 FWD readings
- > 100,000 Longitudinal profile runs
- > 20,000 Distress surveys
- > 70,000 Material tests
- > 6,000 Data exports (7.5 GB)
- > 45,000 Modulus test points

LTPP's CORE FUNCTIONS

1. Data Collection and Management
2. **Data Analysis**

— > Understand Pavement Performance

Purpose of Data Analysis

- Quantify how pavements perform
- Understand why they perform as they do
- Validate and calibrate existing procedures
- Develop new procedures
- Provide quality control of data

Types of Data Analysis Done

- Studies of variability in traffic, materials and performance data
- Development of improved design procedures
- Comparison of pavement performance
- Field validation of pavement design procedures
- ASCE-LTPP data analysis contest

Strategic Analysis Plan Objectives

Traffic characterization and prediction

Materials characterization

Determination of **environmental effects** in pavement design and performance prediction

Evaluation and use of **pavement condition data** in pavement management

Development of pavement response and **performance models** applicable to pavement design and performance prediction

Maintenance and rehabilitation **strategy selection** and performance prediction

Quantification of the performance impact of specific **design features**

Long-Term Pavement Performance Data Analysis Program

LTPP

Strategic Plan Objectives, Analysis Outcomes and Supporting Projects

Strategic Objective 1:

Traffic characterization and prediction

A. Guidelines for data collection (hardware, software, placement, calibration, data collection frequency).

Some elements require work beyond LTPP data analysis, but analysis is needed to provide some components.

H 1

NCHRP 1-39 $ 500,000
Traffic Data collection, analysis and forecasting for mechanistic pavement design.
Aug. 30, 2000

NCHRP 20-50(18) $ 150,000
Performance of WIM Axle Load Data

B. Guidelines for applying traffic loading and classification data in pavement design.

C 2

Problem Statement Number 1B1
Integration of Traffic Inputs for Specific Pavement Applications.
18 months $300,000
To Be Coordinated With NCHRP 1-39

C. Procedures for forecasting and back-casting traffic loading data.

C 3

FHWA $ 543,000
Backcasting to Fill Gaps in LTPP Traffic Data.
Oct. 15, 1998
Sept. 30, 2001

Problem Statement Number 1C1
Procedures for forecasting and back-casting traffic loading data.
$250,000

D. Impact of pavement roughness on the dynamic loads applied to pavements.

H 3

Problem Statement Number 1D1
Tools for analyzing errors and improving accuracy of existing WIM Systems.
24 months $450,000

Strategic Objective 2:

Materials characterization

VH 1

NCHRP 20-50(14) $ 200,000
Significance of "As-Constructed AC Air Voids to Pavement Performance"

FHWA $ 243,000
Review of LTPP materials data.
Sept. 1, 1999

FHWA $ 27,000
Review of LTPP Resilient Modulus Data for Unbound Materials.
June 2000

VH 1

parameters.

FHWA $ 296,000
Backcalculation of Layer Moduli.
Aug. 7, 1997
Dec. 31, 2000

FHWA Review of LTPP Backcalculation Results

Problem Statement Number 2B1
Relationships Between Laboratory and Field Derived Material Parameters.

C. Relationship between as-designed and as-built material characteristics.

H 1

D. Performance impact of different levels of material variability and quality.

H 1

E. Estimate material design parameters from other materials data (for example, Resilient Modulus from gradation and density).

H 1

Problem Statement Number 2E1
Estimation of key base and subgrade engineering properties from index properties, routine tests and physical

Problem Statement Number 2E2
Estimation of key hot mix asphalt and component engineering properties from

Problem Statement Number 2E3
Estimation of key PCC and component engineering properties from

Strategic Objective 3:

Determination of environmental effects in pavement design and

performance.

VH 1

NCHRP 9-23 $350,000
Environmental effects in Pavement Mix and Structural Design Systems.

NCHRP 20-50(7/12) $ 540,000
Rigid Pavement Sensitivity and Material Properties

FHWA $ 94,000
Evaluation of Pavement Temperature Data.
Oct. 1998

FHWA $ 76,000
Interpretation of TDR Data.
Nov. 1, 1996

FHWA
Seasonal Variations in Unbound Materials.
May 1997

Problem Statement Number 3A1
Assessment of the Individual Effects of loading and environment on Pavement Distress.

Problem Statement Number 3A2
Temporal effects of environmental factors in determining overload damage. (after NCHRP 20-50(5))
30 months $400,000

VH 1

FHWA $ 142,000
Determination of Depths of Frost and Thaw Penetration.
Nov. 1, 1996

2002

Problem Statement Number 3B1
Effect on Performance of Multiple Freeze-Thaw Cycles vs. Deep Frost Penetration.

Problem Statement Number 3B
Pavement damage caused by swelling and frost susceptible soils. Validate mechanistic indices to characterize the effects of frost and swell.

C. Long-term changes in pavement characteristics due to environmental effects and aging.

H 1

Problem Statement Number 3C
Evaluation of the integrated climatic model using LTPP Seasonal Monitoring Project (SMP) data.

Problem Statement Number 3C
Determine the applicability of mechanistic design methods. Assess the effect of environment on pavement materials to ... assumptions are valid.

VH 2

FHWA
Verification of LTPP Virtual Weather Stations.

E. Region Specific guidelines for considering environmental and load effects.

H 2

Problem Statement Number 3E1
Region Specific Guidelines for Pavement Modeling and Design Considering Environmental Effects.

Problem Statement Number 3E
Effects of load and environment on highway cost allocation.

Strategic Objective 4:

Evaluation and use of pavement condition data in pavement

VH 1

NCHRP 1-33A $ 149,923
Guide for Pavement Management.
Dec. 1, 1997
Completed June 1, 2000

FHWA $ 141,000
Consolidated Distress Data.
Aug. 15, 1998
Dec. 31, 2000

FHWA $ 397,000
Longitudinal Profile variability.
July 28, 1997

FHWA $ 96,000
Joint Faulting Data Analysis.
June 28, 1998

FHWA $ 196,000
Study of Transverse Profile.
July 26, 1997

TBD TBD/Richter
Problem Statement Number 4A1
Integrating Condition Measurement Variability in Network PMS.

Problem Statement Number 4A2
Develop improved pavement performance default values or models for life-cycle cost determination.

Problem Statement Number 4A3
Develop hierarchical data collection for network- and project-level pavement management considering types and

Problem Statement Number 4A4
Develop numerical pavement evaluation indices for both AC and PCC pavement to characterize the most common pavement condition (distresses).

VH 2

FHWA $ 100,000
Study of LTPP Pavement Deflections.
Oct. 1998

TBD TBD/Richter
Problem Statement Number 4B1
Simplified Techniques for Evaluation and interpretation of pavement deflections for network-level analysis.
18 months $200,000

C. Models relating functional and structural performance.

H 2

Problem Statement Number 4C1
Relating Ride Quality and Structural Support for Pavement Rehabilitation Design Decisions.
12 months $ 200,000

D. Criteria for applying performance measures (including variability) to construction quality evaluation.

H 2

NCHRP 20-50(3) $ 132,000
Feasibility of Using FWD Deflection Data to Characterize Pavement Construction Quality.
Nov 2, 2001

Problem Statement Number 4D1
Early performance criteria for pavement construction warranties. Provide early performance data to assist states in

E. Relationship between variation in pavement performance measures and environmental factors.

H 2

Problem Statement Number 4E1
Using SMP data, analyze and quantify information on the effects of environmental variables on pavement performance measures.

Strategic Objective 5:

Development of pavement response and performance models applicable to

prediction.

acceptable level of risk, and model complexity.

VH 1

NCHRP 1-37A $ 3,986,396
Development of the 2002 Guide for the Design of new and rehabilitated Pavement Structures (Phase II).
Feb. 1, 1999

FHWA $ 50,000
Review of LTPP Dynamic Load Response Data.
Dec. 1999

Problem Statement Number 5A1
Evaluation of load-response models (axle load and environment).

distresses.

VH 1

NCHRP 20-50(6) $ 280,000
Variations in Pavement Design Inputs
Oct. 13, 1999

Problem Statement Number 5B1
Evaluation of the Performance Prediction Models in the 2002 Pavement Design Guide.
24 months $ 400,000

distress types.

VH 1

Problem Statement Number 5C1
Verification of reflective cracking models.
24 months $ 200,000

Strategic Objective 6:

Maintenance and rehabilitation strategy selection and performance

A. Performance and efficacy of maintenance and rehabilitation treatments as a function of pre-treatment condition.

C 1

NCHRP 20-50(4)
Effectiveness of maintenance and rehabilitation

FHWA $ 54,000
Review of Pavement maintenance & Rehabilitation Data.
Oct. 11, 1999
Nov. 2000

B. Guidelines for timing and selection of pavement maintenance and rehabilitation options, and expected performance impacts of each.

C 2

NCHRP 1-38 $ 100,000
Guide on Pavement Rehabilitation Strategies.
March 1, 1999

NCHRP 14-14 $ 500,000
Guide for optimal timing of pavement preventive maintenance treatment applications.
Aug. 10, 2000

Problem Statement Number 6B1
Guidelines for selecting pavement rehabilitation strategies.
(after 2002 – Build on 20-50(3/4))
18 months $750,000

Strategic Objective 7:

Quantification of the performance impact of specific design features (presence of ...

levels of pre-rehab surface preparations.

VH 1

NCHRP 20-50(2) $ 100,000
Relative Performance of Jointed Plain Concrete Pavements with Doweled and Undoweled Joints
July 28, 1999

FHWA $ 360,000
Review of SPS 1, -2, -5 and -6 Experiments.
July 12, 1999
Dec. 31, 2000

FHWA $ 191,000
Review of Layer Thickness Data.
Sept. 1, 1999

2002

Problem Statement Number 7A1
The Impact of Design Features on Pavement Responses for New Flexible and Rigid pavements.

Problem Statement Number 7A2
SPS-6 Impact of Design Features on Response in Rehabilitated Pavement.

VH 2

NCHRP 1-34A $ 149,923
Contributions of Pavement Structural Layers to rutting of Flexible Pavements.
June 18, 1999

NCHRP 1-34C White-Haddock/Hogan
Effects of subsurface drainage on performance of asphalt and concrete pavements.
April 6, 2000

NCHRP 20-50(1)
Factors affecting pavement smoothness
Oct. 20, 1999

NCHRP 20-50(10)
Performance of asphalt and rigid pavements

TBD TBD/Richter
Problem Statement Number 7B1a
Determine the impact of design features on pavement distress for new flexible pavements.
24 months $300,000

Problem Statement Number 7B1b
Determine the impact of design features on pavement distress for new rigid pavements.
24 months $300,000

VH 3

Priorities

Critical

Very High

High

Sequence

Sequence numbers denote the order in which Analysis Outcomes should be addressed for a given Objective. Analysis Outcomes with the same sequence number can be addressed at the same time.

NCHRP project number $ Funds
NCHRP project title
Effective date
Completion date

NCHRP project number $ Funds
NCHRP project title
Effective date
Completion date

Problem Statement Number O_A_n
Proposed problem title.
Project duration Anticipated project funds

Light Blue boxes are on-going NCHRP projects that were initiated by the LTPP ETG.

Pink boxes are on-going NCHRP projects that were initiated by other agencies or work groups, but are directly associated with LTPP Data Analysis Plan Strategic Objectives and Analysis Outcomes.

Dashed white boxes are proposed Research Problem Statements that were developed at LTPP Workshops. See Note 1) for an explanation of the Problem Statement Numbering scheme.

FHWA Technical Support Contract $ Funds
Project title
Start Date

2003

Solid Orange boxes are on-going FHWA projects that were funded using LTPP budgeted funds.

Hashed Orange boxes are planned FHWA projects that will be funded using LTPP budgeted funds.

Highlighted boxes identify Problem Statements that have been selected for inclusion in the proposed LTPP Data Analysis Program for the year indicated.

Note

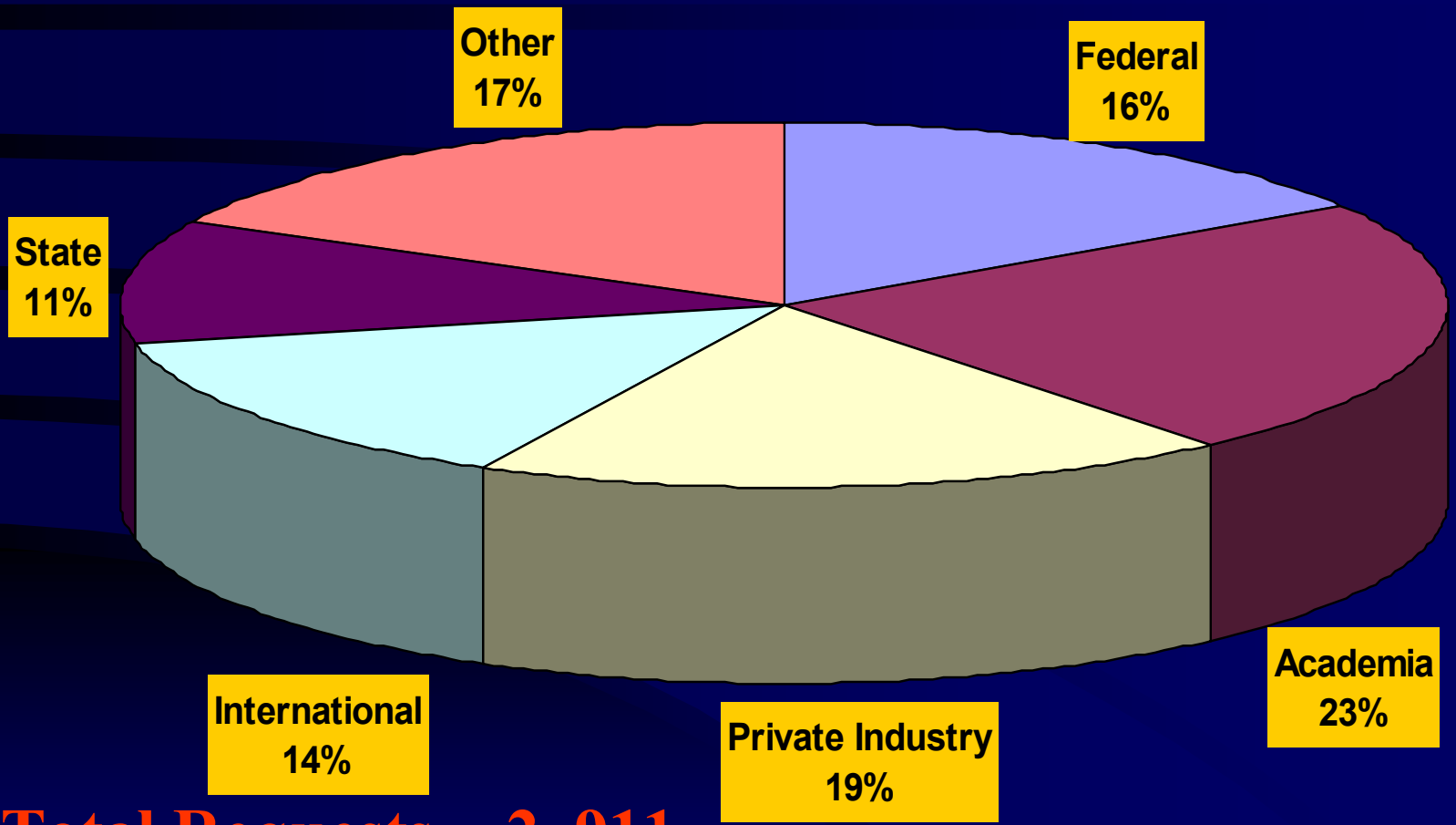
1) Problem Statements are assigned a 3 character number using the convention 'O_A_n'. 'O' is the associated Strategic Objective number (1 through 7); 'A' is the associated Analysis Outcome letter (A, B, C etc.) and 'n' is an arbitrarily assigned number used for identification purposes. The number 'n' does not imply a sequence in which Problem Statements should be addressed.

LTPP

April 20, 2001

Customer Requests: 1997 - 2003

Requests by Organization



Total Requests = 2, 911

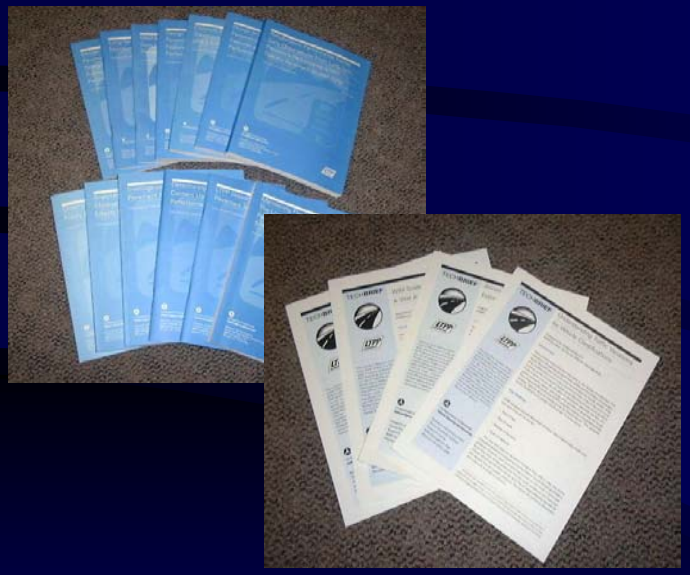
LTPP's CORE FUNCTIONS

1. Data Collection and Management
2. Data Analysis
3. **Communication**

→ Ensure Access to LTPP Program Information

Communication Tools

- Meetings
- Workshops/Contests



- Publications
  - ✔ Brochures
  - ✔ TechBriefs
  - ✔ Product Briefs
- Research Reports
- Products
- Videos
- Website

LTPP's CORE FUNCTIONS

1. Data Collection and Management
2. Data Analysis
3. Communications

4. Product Development

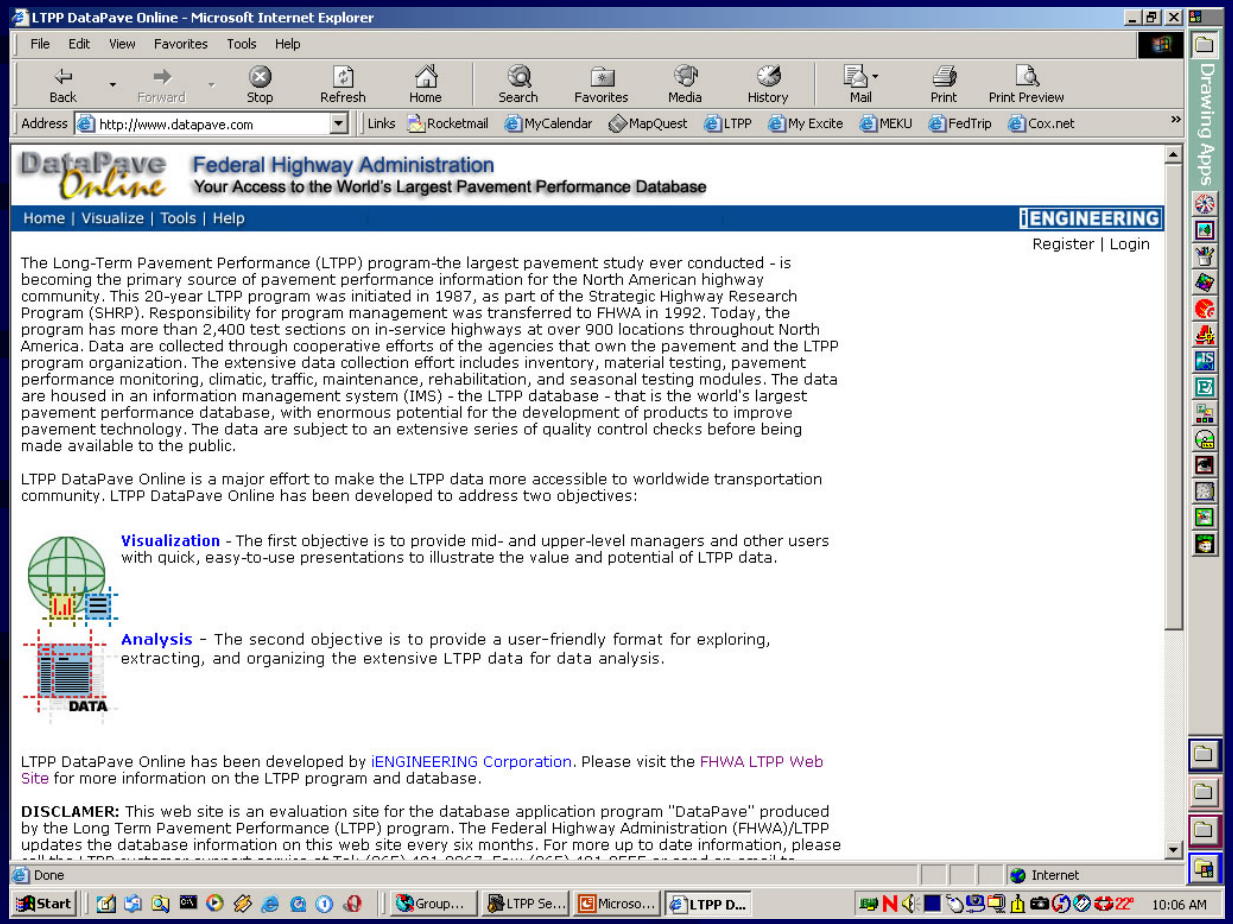
→ Develop and Deliver Usable Tools

LTPP Products

Some Products …

- LTPPBind
- Resilient Modulus CDROM
- FWD Calibration Procedures
- Manuals of Practice
- SMP CDROM
- Guidelines for FWD Temperature Adjustments
- Rigid Pavement Design Software
- ProVal
- DataPave online

Access to the Data



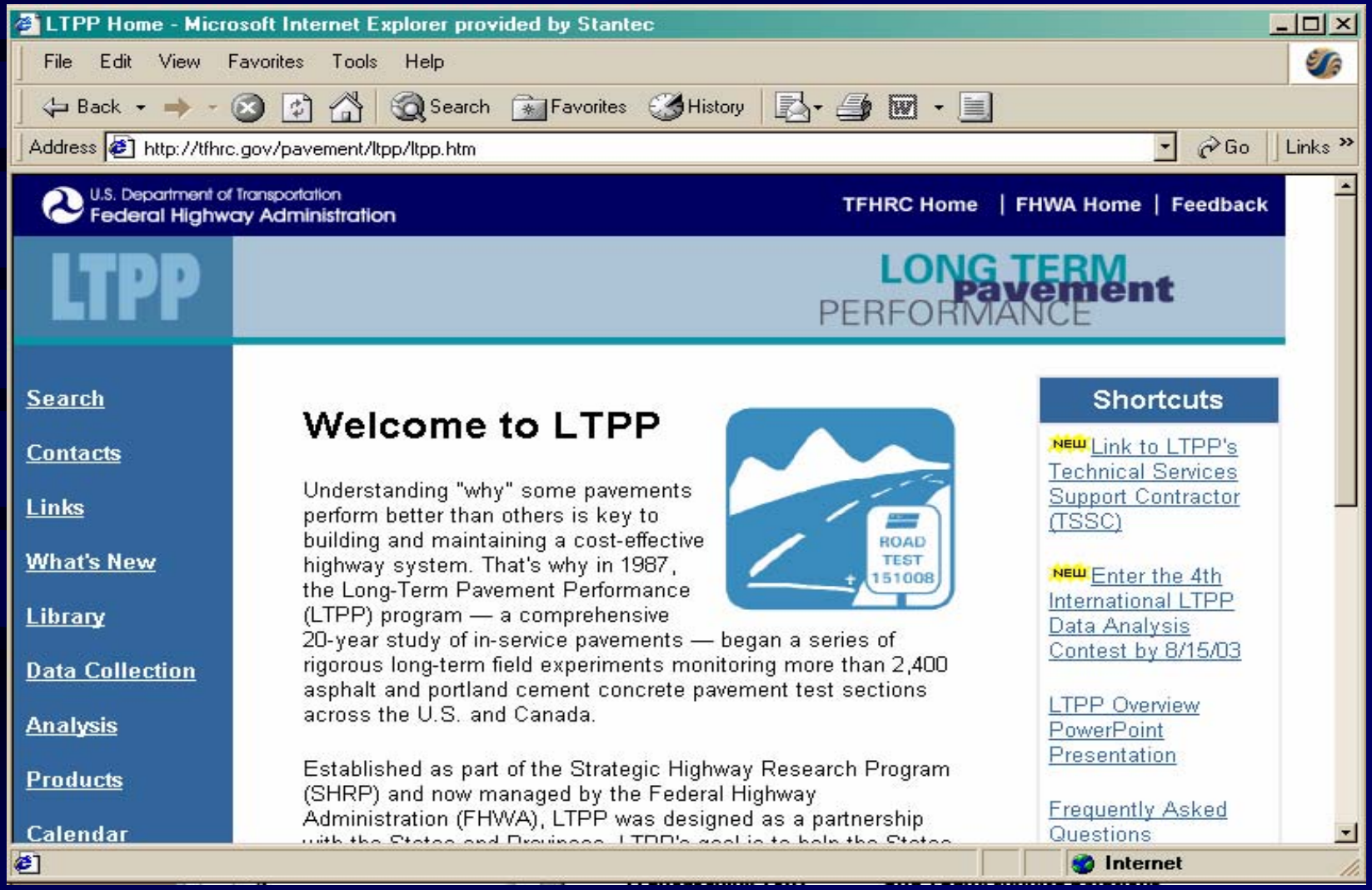
Closing Comments:

- LTPP & New Pavement Design Guide
- Where to go to get more LTPP Info.

LTPP's Role in the New Design Guide

- Validation and Calibration
- Material Characterization
  - LTPP soil Mr test procedure
  - Source of typical values
- Environmental Effects
  - Source of climatic data
- Evaluation of Existing Pavements
  - LTPP's backcalculation procedure
  - FWD calibration procedures

LTPP on the Web



Connect to LTPP Webpage through

http://tfhrc.gov/pavement/ltpp/ltpp.htm

Some LTPP Websites:

FHWA-LTPP Homepage:

- www.tfhrc.gov/pavement/ltpp/ltpp.htm

LTPP Technical Support Services

- www.ltpp.org

DATAPAVE on line:

- www.datapave.com

LTPP - North Central Regional Office (NCRO)

- www.stantec.com/ltpp/ncro

→ **Email:** *LTPPINFO@fhwa.dot.gov*

THANK YOU

Hardcopies:

- LTPP Data Analysis Plan
- LTPP Website Addresses