Implementing Mechanistic-Empirical Pavement Design and DARWin-ME

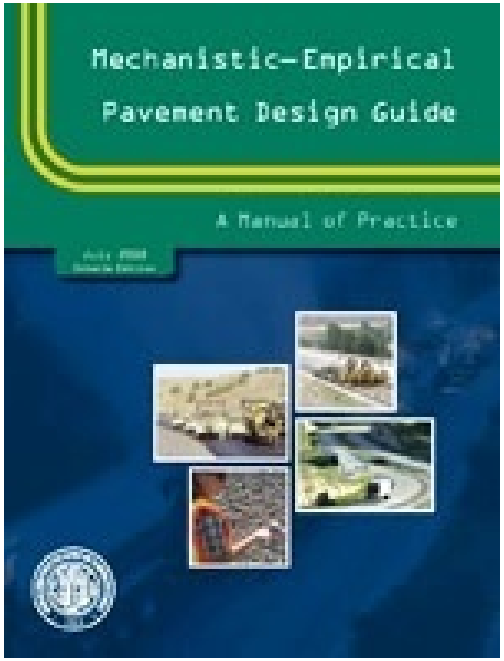
National Concrete Consortium
September 13-15, 2011
Rapid City, South Dakota

Overview

- Summarize information contained in the FHWA white paper titled "Implementing the DARWin-ME: Pavement Design Software to Support the MEPDG"
  - Brief overview of the application and use of the MEPDG
  - Snapshot of activities nationwide related to MEPDG implementation
  - Summary of benefits in using DARWin-ME Software
- Summarize information from three State DOT case studies (MO, IN & MT)
- Steps to successful implementation

Outline

- Introduction & DARWin-ME™ Benefits
- Implementation Activities & Steps
- Calibration & Validation
- Implementation Studies/Efforts
- Lessons Learned from Implementation & Recommendations
- Planning for the Future



DARWin ME™
Mechanistic Empirical Pavement Design

MEPDG & DARWin-ME History

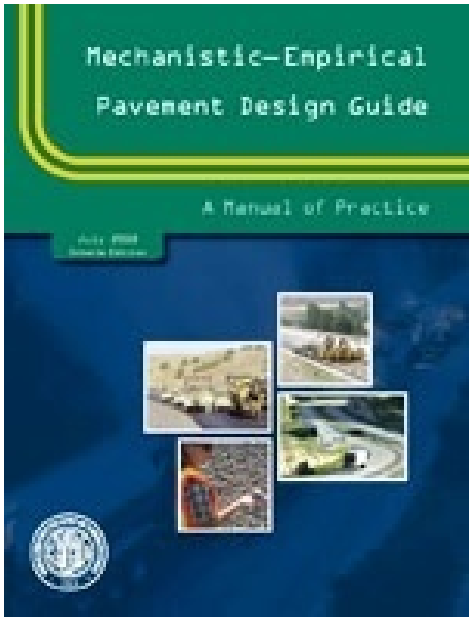
- MEPDG history:
  - Work product of NCHRP projects 1-37A and 1-40D
  - Nearly a decade of development at cost > $10M
  - Covers 17 pavement design situations—new & rehab
  - Adopted as AASHTO's Interim Pavement Design Guide in 2008
- MEPDG related software:
  - Base software: Freeware, available through Transportation Research Board until 2012
  - DARWin-ME: Production-level software in support of AASHTO's MEPDG

What is DARWin-ME?

A tool to provide the transportation community with a production level, state-of-the-art software tool for the design of new and rehabilitated pavement structures consistent with AASHTO's Interim MEPDG.

DARWin ME™

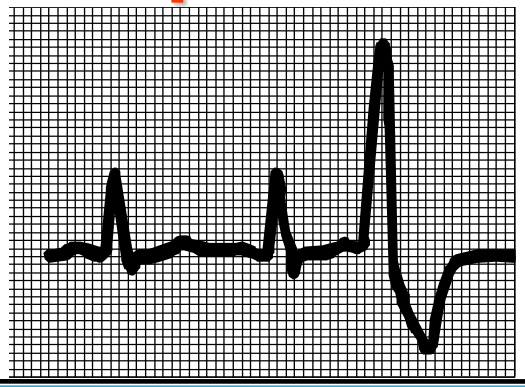
Mechanistic Empirical Pavement Design



What is DARWin-ME?

DARWin-ME calculates pavement responses to predict pavement distresses and smoothness loss overtime for both HMA & PCC surfaced pavements through the use of transfer functions.

Pavement Response

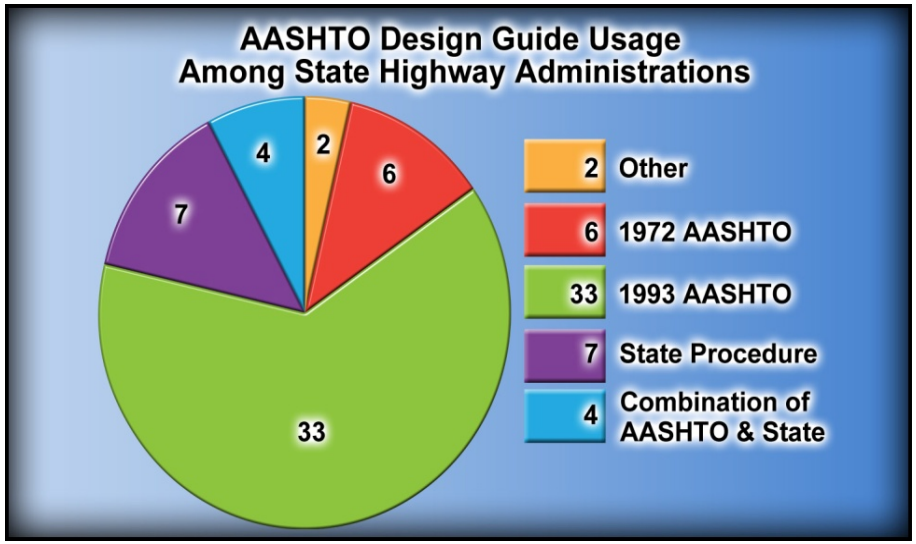


TRANSFER FUNCTION

Distress

Why Implement the MEPDG?

Pavement Design Practice as of 2007



Factors Leading to MEPDG Development

- Current AASHTO Guide:
  - Produces conservative designs for high truck volume roadways
  - Cannot handle rehabilitation adequately
  - Cannot adequately consider all modern design features, materials, loadings
  - Is thickness-centric

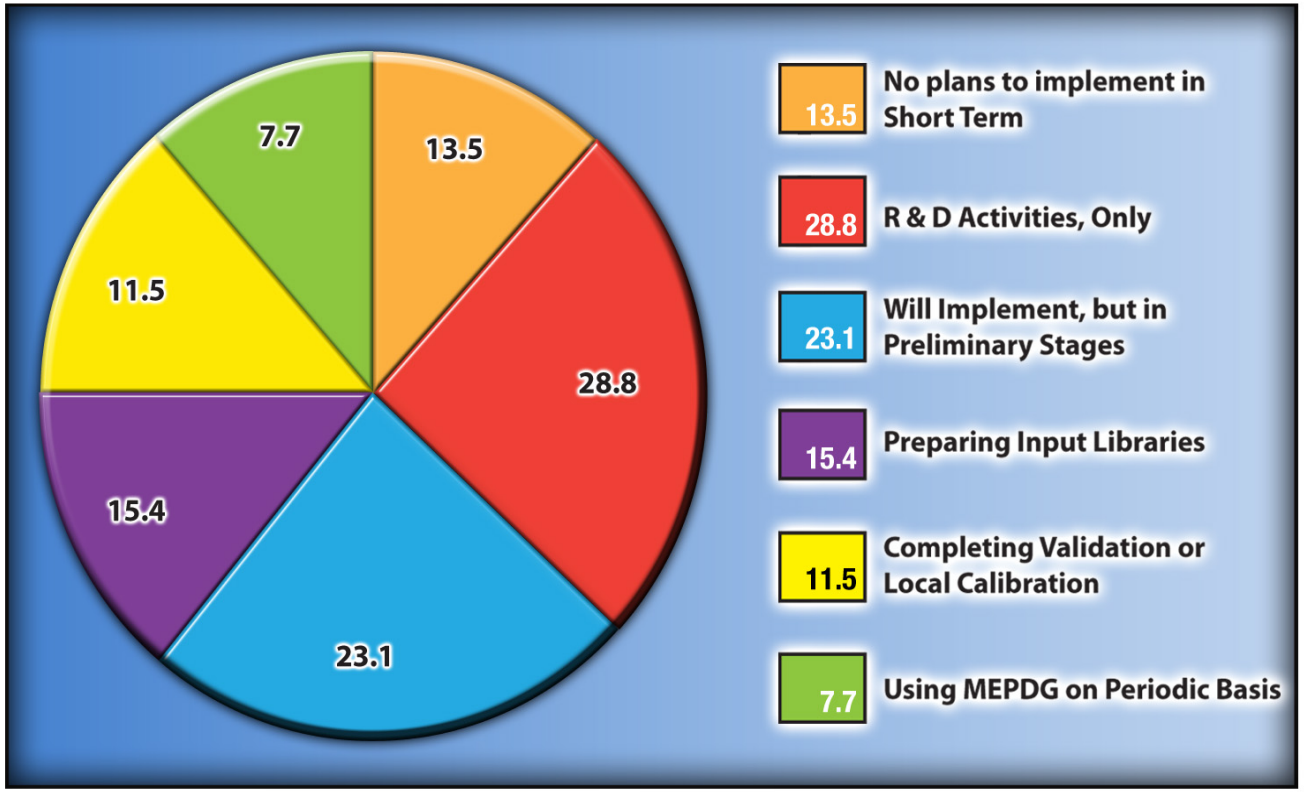
How can DARWin-ME Help?

- Evaluate design features and strategies for optimizing design other than thickness.
- Designs based on agency-established performance criteria which can be tracked during the use phase.
- Output can be used in life cycle cost analyses and performance related specifications.
- Ability to consider newer materials.
- Considers interaction between materials, structure, construction parameters, climate, and traffic.

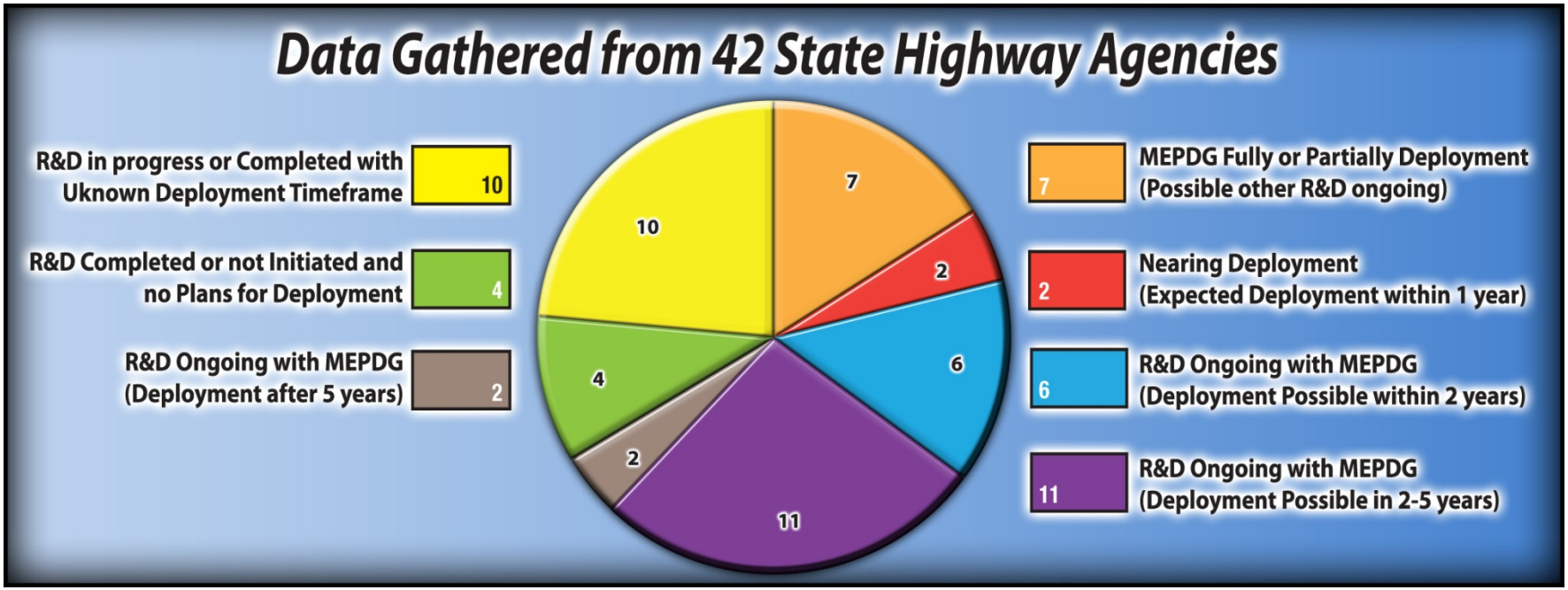
How can DARWin-ME Help?

- It has the ability to quantify additional damage caused by unique truck loading configurations or increased truck weights.
- It can consider unique design features and strategies, not just pavement thickness.
- It determines the most cost-effective strategies.
- The designs are based on agency-established performance criteria which are measured through the life cycle of the pavement.
- Its output can be used in life-cycle cost analyses and performance related specifications, as well as in establishing warranties.

Snapshot of MEPDG Implementation Activities



Summary of DARWin-ME Deployment



Implementation Approaches, Activities & Steps

Approaches to Implementation

Category 1:

- Less time and effort for implementation, focus on developing and measuring key inputs and performing limited verification or sensitivity studies.
- It includes validation efforts using data from readily available pavement sections to ensure that the transfer functions predict reasonable distress levels .

Most agencies are in this category.

Approaches to Implementation

Category 2:

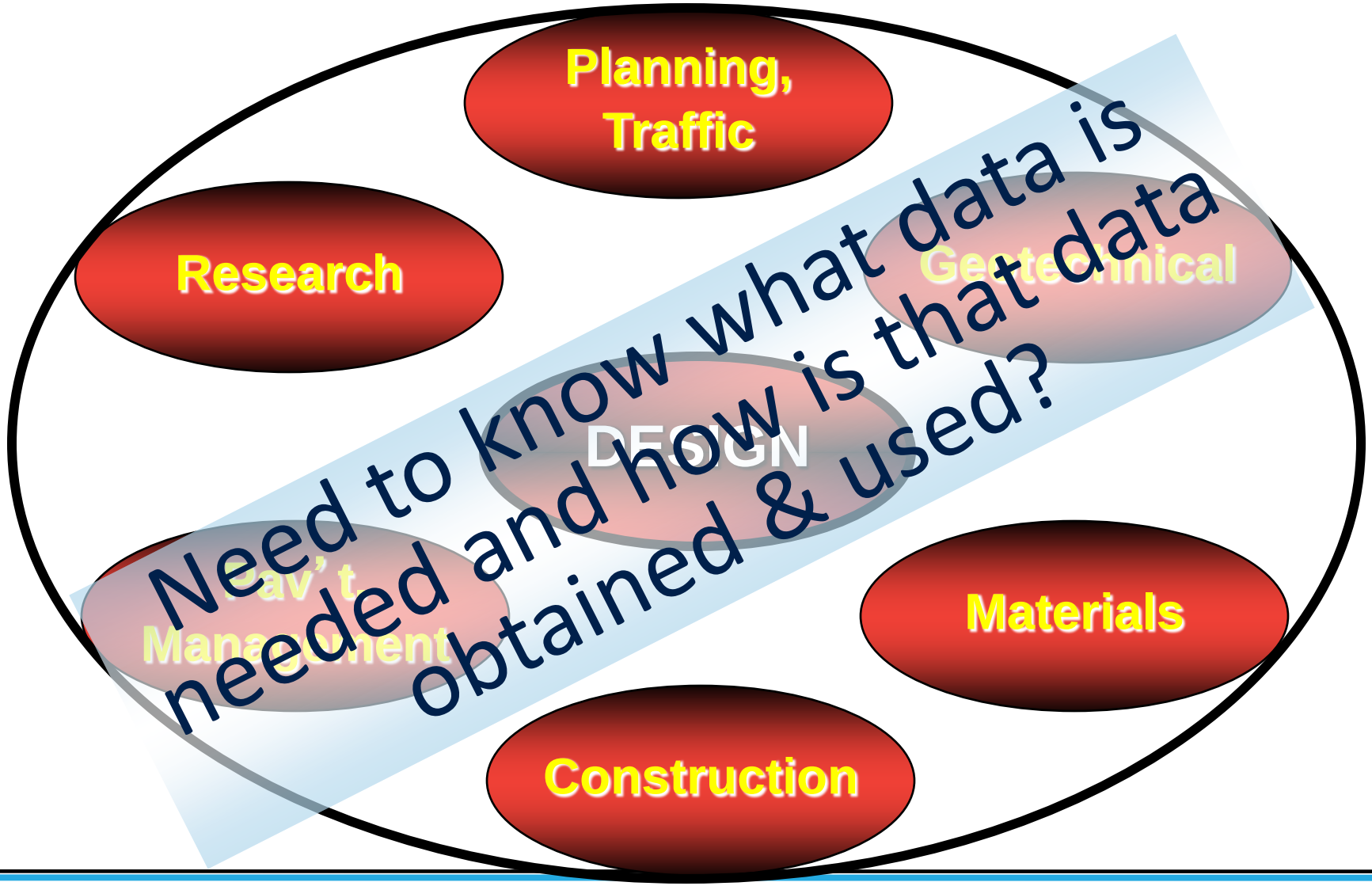
- Extensive effort & time to complete a full local calibration of the MEPDG as part of the implementation process.
- This involves activities for creating more comprehensive input libraries for traffic, materials, and climate inputs; creating design automation tools such as data libraries for MEPDG-specific input files; and conducting extensive field and laboratory testing activities.

Key Steps of an Implementation Program

Critical Steps/Elements:

1. A champion to lead the implementation effort and program.
2. Develop a roadmap to success.
3. Complete concurrent designs.
4. Establish communication lines – input parameters.

Communications



Key Steps of an Implementation Program

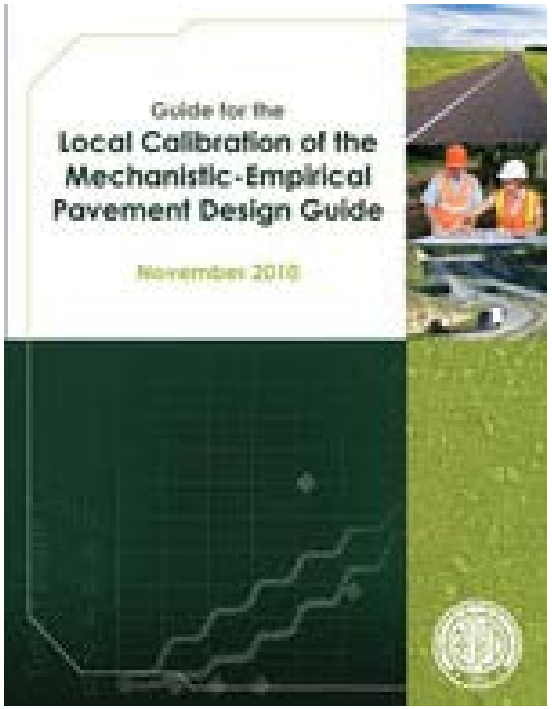
Critical Steps/Elements:

5. Participate in & establish training programs.
6. Build libraries for common input parameters.
7. Conduct local/regional validation/calibration studies.
8. Provide funding/support personnel.

Calibration and Validation

Local Validation-Calibration of Transfer Functions

How close is close enough?
A difficult & case-specific issue to address!



Preparing a Calibration-Validation Plan

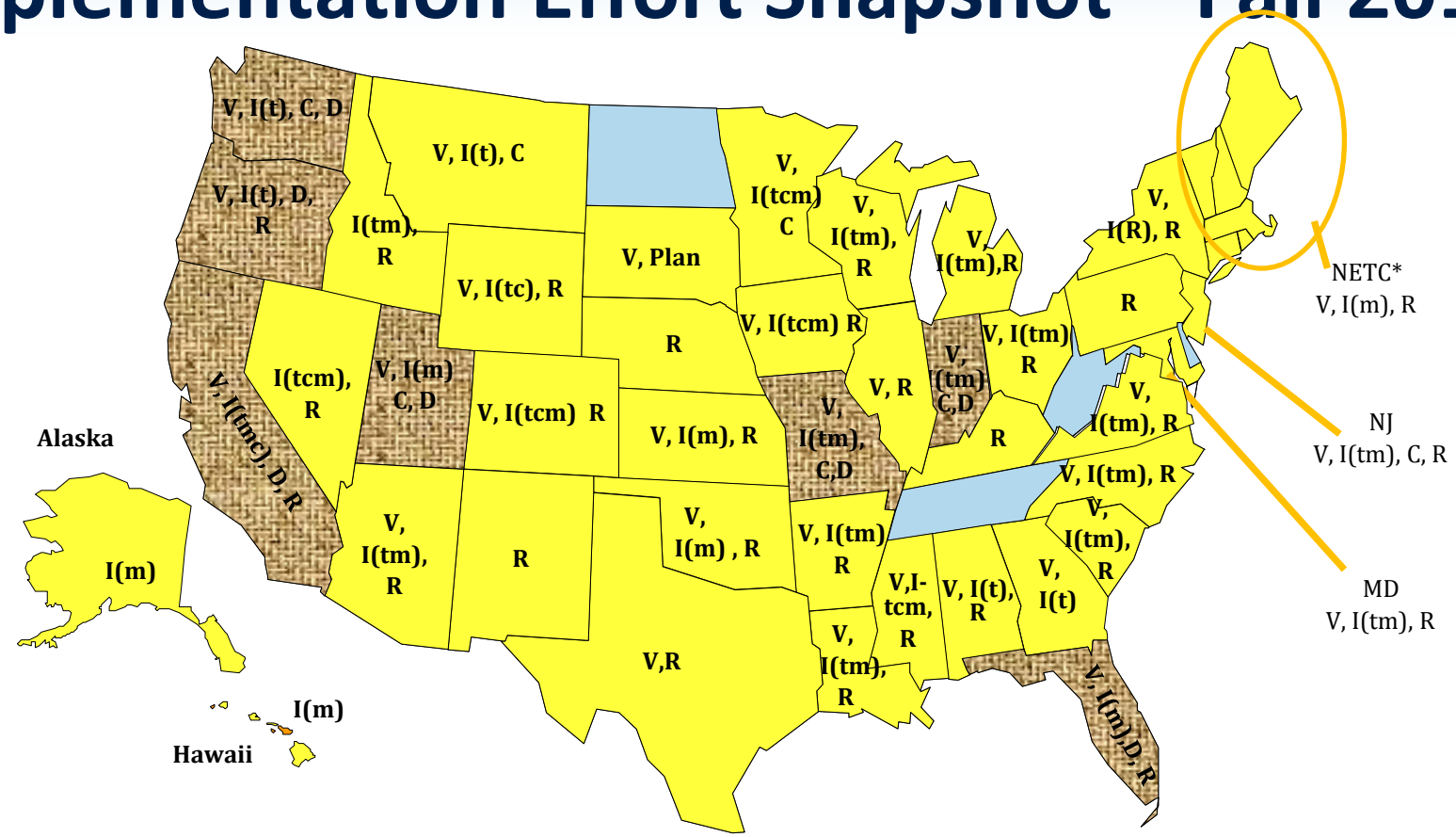
1. Adequate sample size
2. Forensic investigation of sites
3. Analyses of performance data
4. Quantify error components

Validation-Calibration

- In summary – it is your choice and an engineering decision
- Regional validation-calibration efforts are encouraged as a minimum

Examples of Implementation Studies & Efforts

Implementation Effort Snapshot—Fall 2010



No data available: DE, ND, TN, WV; *NETC = New Eng. Trans. Consortium

D	= MEPDG Deployment (either partial or full)
R	= Research ongoing
Plan	= Formal implementation plan developed
V	= Model Verification Studies
I(tcm)	= Input characterization
C	= Calibration completed

Selected Studies & Efforts Related to Implementation

Formal Implementation Plan for Implementing MEPDG

- Alabama, Arizona, Arkansas, Colorado, Iowa, Maryland, Mississippi, Montana, North Carolina, Utah

Sensitivity Studies

- NCHRP project 1-47, Arkansas, Maryland, Michigan, Nebraska, Texas

Selected Studies & Efforts Related to Implementation

Material Input Libraries

HMA

- Arkansas, Colorado, Florida, Indiana, Illinois, Iowa, Kansas, Mississippi, Missouri, Minnesota, New Jersey, North Carolina, Virginia, Washington

PCC

- Arkansas, Colorado, Florida, Indiana, Iowa, Pennsylvania, Wisconsin

Unbound Materials

- Florida, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Montana, New Jersey, Oklahoma, Virginia

Selected Studies & Efforts Related to Implementation

Traffic – Determination of Regional/Local Input Libraries

- Alabama, Arizona, Arkansas, California, Indiana, Michigan, Mississippi, North Carolina, Virginia

Validation-Calibration; Determination of Local Calibration Factors

- Arizona, Arkansas, Colorado, Mississippi, Missouri, Montana, Utah

Lessons Learned from Implementation & Recommendations

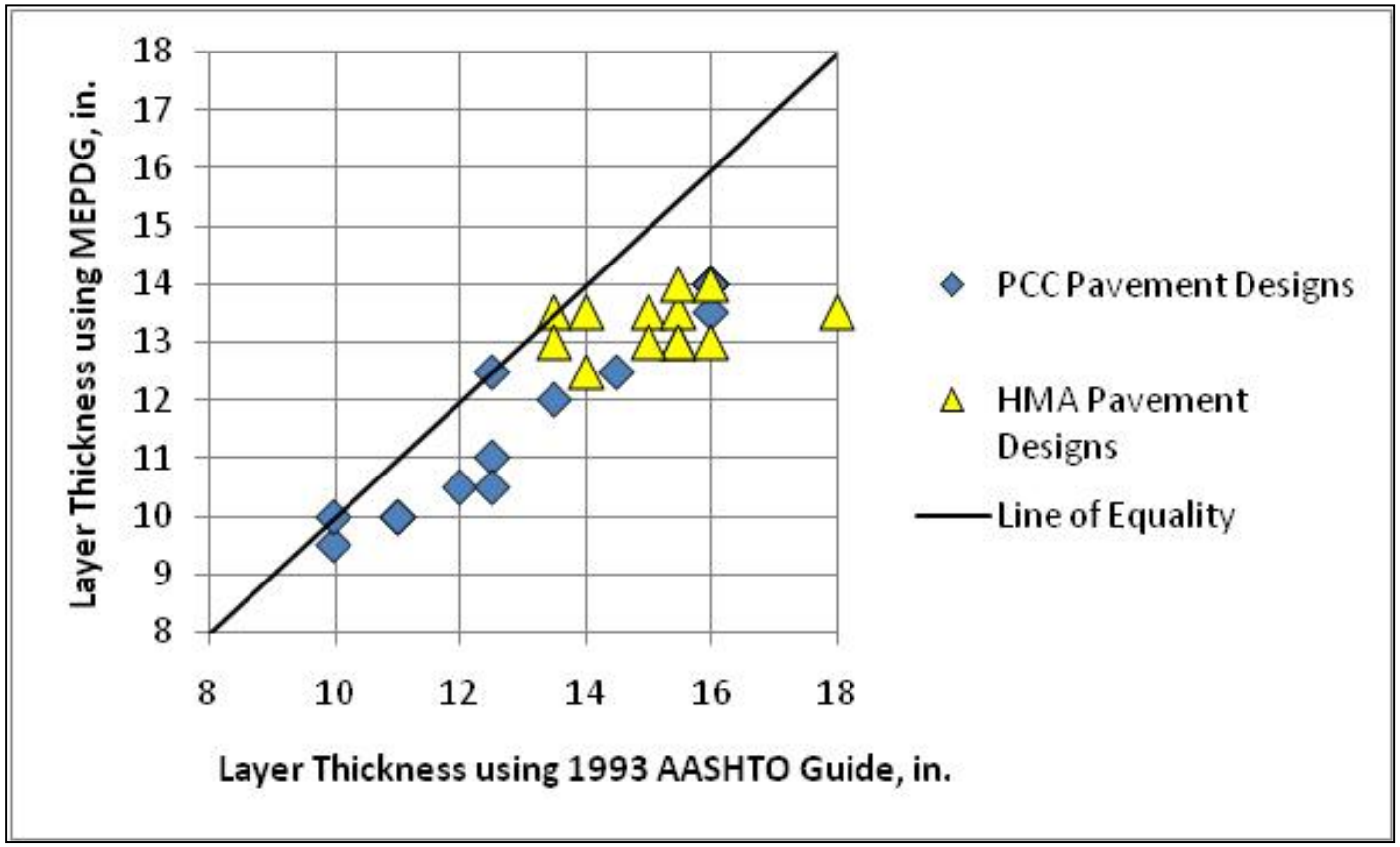
Case Study Document

- Indiana
- Missouri
- Montana

Lessons Learned: Impact & issues of Implementation from these agencies.

Lessons Learned from Implementation: What has been the Impact?

- Thinner pavements for higher volume roadways



Lessons Learned from Implementation: What has been the Impact?

- Ability to use construction specification values in design and understand effect of changing specification
- Minimum layer thickness from MEPDG considered reasonable based on historical performance data
- Preventive maintenance is cost effective in extending pavement service life
- Savings in initial construction costs

Lessons Learned from Implementation: What were the issues?

- Expect more time to be spent on design
- Input values need to be scrutinized & checked – they are different than what has historically been used
- Distress definitions/measurements were difficult to deal with at the beginning
- Preventive maintenance activities make it difficult for calibrating the MEPDG
- Local calibration is complicated – it is more than just number crunching

Recommendations from Selected Agencies

- Appoint a champion or leader for using and implementing the MEPDG
- Prepare a step-by-step procedure to run the software
- Make sure that the agency's pavement design manual is updated to be consistent with MEPDG
- Tie the material specifications to the material inputs
- Start building the traffic & materials libraries & then think about local calibration

Recommendations from Selected Agencies

- Lack of coordination and communication between divisions within an agency can be a real challenge
  - Coordination and communication are critical and must be emphasized.
- Reviewing designs is important
  - Make sure all inputs are checked!
- Focus on application for design and not analysis

Recommendations from Selected Agencies

- Do not expect to start using the MEPDG for design right away
  - Use of the MEPDG requires training in different areas
  - Plan on increasing the designer's knowledge of pavement design and material characterization
  - Use of the MEPDG requires a basic knowledge of pavements and materials characterization

Recommendations from Selected Agencies

- For agencies that permit consultants to complete the designs:
  - Plan on a lot of time for checking and reviewing the inputs for errors and mistakes
  - Consultants should be required to take training prior to using the MEPDG
- Designate in-house staff for troubleshooting the software and be available for answering questions with the software and hardware

Recommendations from Selected Agencies

- Agencies need to consider as part of implementation and adoption of the MEPDG its use as related to construction
- The training demonstrations that FHWA put together were worthwhile
  - These demonstrations had more immediate benefit to States that were not very familiar with M-E based methods

Recommendations from Selected Agencies

- The process, including local calibration, is complicated. Understand the inputs and their importance related to the distresses predicted by the MEPDG.
- Durability, non-load related distresses, and construction defects are important but not considered by the MEPDG.

Planning for the Future

Planning for Future Updates

1. Maintain calibration-validation database along with the input libraries.
2. Periodically monitor test sections & input parameters & update database.
3. Verify local calibration or agency specific factors for future DARWin-ME versions.

Previous & On-Going Studies

- Calibration Documents:
  - **NCHRP Digest 283**, December 2003; *Jackknife Testing – An Experimental Approach to Refine Model Calibration and Validation*
- FHWA sponsored projects:
  - Use of PMS data for local calibration
  - Traffic Input Workshops, ongoing
  - PREP-ME Pooled Fund Project - TPF-5(242)
  - Use of deflection basin data in the MEPDG & backcalculation of layer moduli

Questions

- www.trb.org/mepdg
- www.fhwa.dot.gov/pavement

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