

NATMEC-2010

ARKANSAS' IMPLEMENTATION OF THE MEPDG

Presented by
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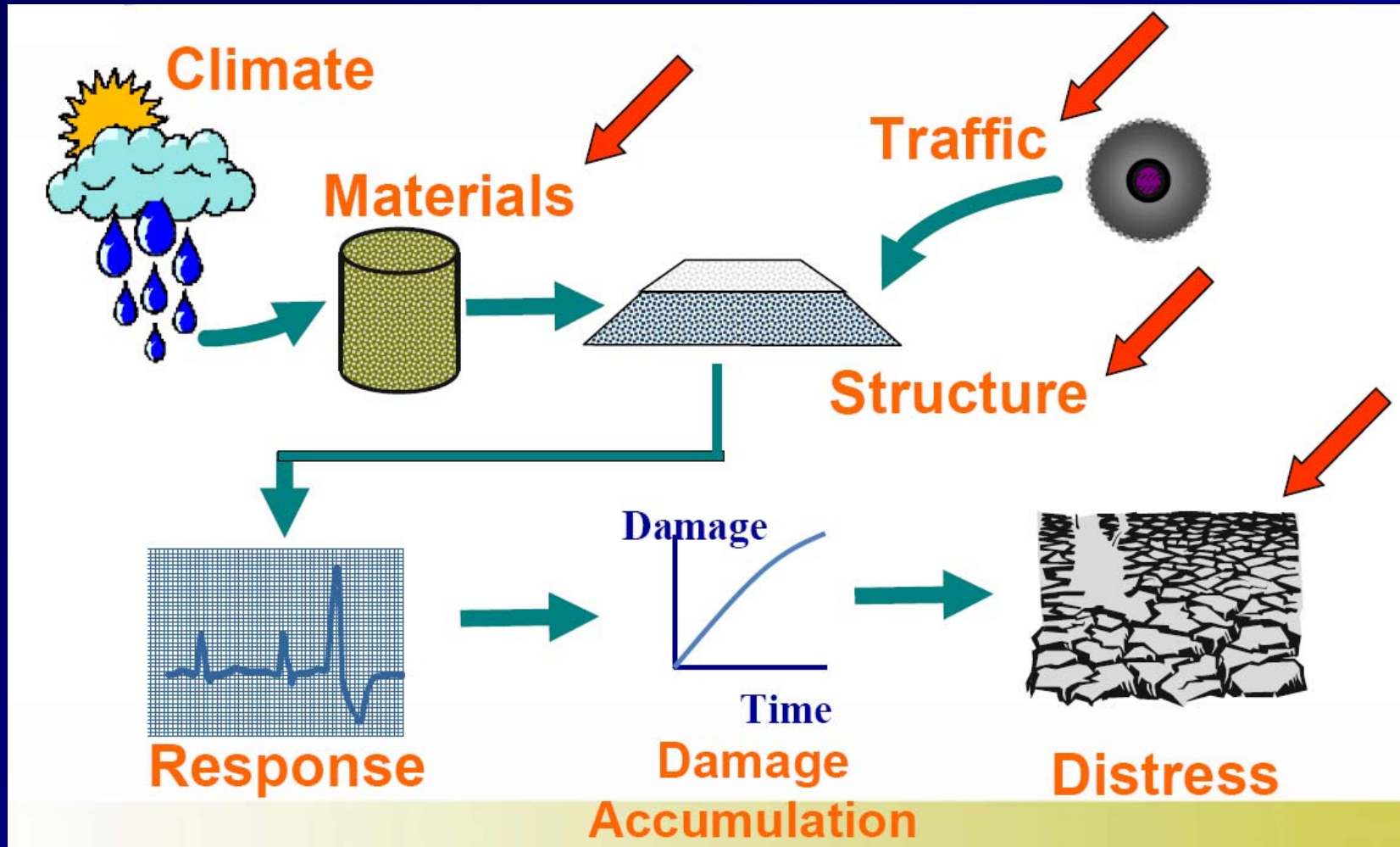
University of Arkansas



The Outline

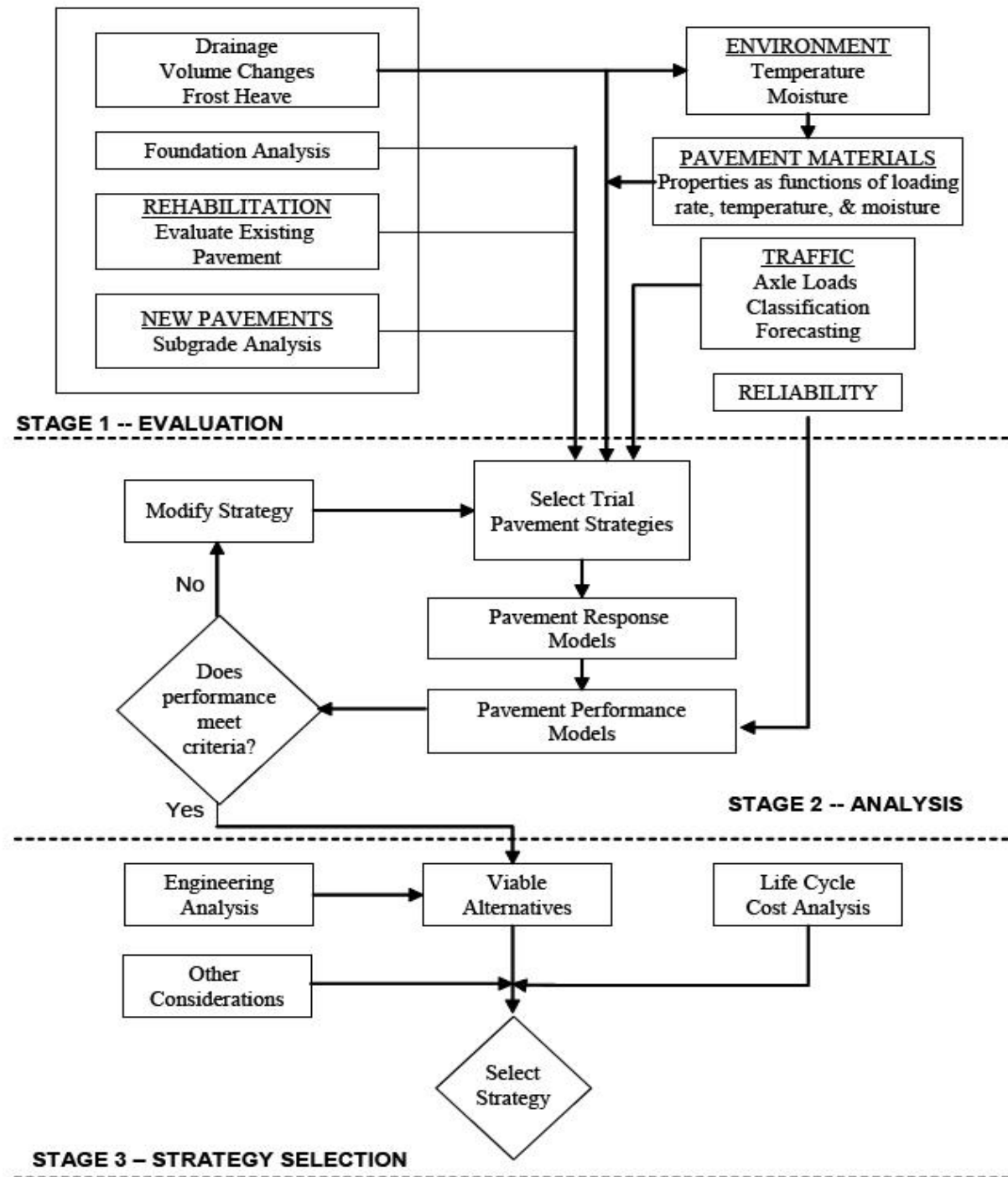
- Overview of the MEPDG
- Arkansas' Approach
- Status/Direction
- Future Work

Mechanistic Empirical Pavement Design Guide (MEPDG)



Mechanistic Empirical Pavement Design Guide (MEPDG)

NCHRP 1-37A, 2004



Key Advantage of M-E Design

- “Comprehensive” design procedure
- Not Just Thickness
- Accounts for many factors that change over time (traffic, climate, materials)
- Improved traffic characterization
- Improved structural modeling capabilities
- Improved materials characterization

Key Advantage of M-E Design

- Allows the prediction of key distress types as well as roughness over time based upon analysis on fundamental materials properties and M-E principles
- Tool for forensic analysis

Design Inputs –3 Main Categories

■ Traffic

- Volume
- Axle load distribution
- Axle configuration

■ Climate

- Latitude, longitude, elevation, etc.

■ Structure

- Layers, thicknesses, and material properties

Design Input Levels

■ Level 1

- Site and/or material specific inputs

■ Level 2

- Use of correlations to establish or determine the required inputs

■ Level 3

- Use of national or regional default values to define the inputs

Arkansas' MEPDG Activities

- “First Look” (Hall)
 - Sensitivity Analyses
- Material Characterization (Hall)
 - Hot-mix asphalt
 - Portland cement concrete
 - Unbound materials
- Traffic Characterization (Hall)
- Design Studies (Hall)
- Database Development (Wang & Hall)
- Local Calibration Research (Hall & Wang)

Sensitivity Analyses

- Identify those inputs most critical in distress predictions
 - Provided a “head start” to material characterization studies
- Numerous studies completed around the US to date
- NCHRP 1-47

Materials: Hot-Mix Asphalt

- Dynamic Modulus (E^*)
 - 3 NMAS (Nominal Maximum Aggregate Size)
 - 3 Binder Grades
 - 4 Aggregate Types
 - 2 Gradations
- Created catalog of E^* data for “Level 1” design
- Assessed suitability of Level 3 predictive equation



Materials: PCC

- Coefficient of Thermal Expansion (CTE)
- Poisson's Ratio
- Modulus of Elasticity
 - 5 Aggregate Types
 - Time Series Value
- Effect of Paste
- Catalog of Values
- Assessment of Predictive Relationships



Materials: Unbound

- Granular Base
 - 10 Aggregate Types
 - Shear Properties
 - Elastic & Resilient Modulus
 - Poisson's Ratio
- Subgrade Soils
 - Resilient Modulus
 - Relationship between Modulus & R-value

Traffic Studies

■ The Good...

- 7 TTCs identified statewide
- Default monthly and hourly distribution factors suitable for use
- Developed statewide vehicle class distribution factors
- Developed statewide Axle Load Spectra
- PrepME software generates 11 traffic files for use

■ The Ugly...

- Only 25 of 55 WIM sites suitable for traffic study
 - ❖ Classification data: 17 of 25 sites passed quality checks
 - ❖ Weight data: 10 of 25 sites passed quality checks

Weight Data Check Window

PrepME-Traffic Weight Data Check

MEPDG Supporting Database File for Quality Control
 F:\TRC-0702, AASHTO-Web Meeting on May 27th 2009\Database\AR-05-19-09.mdb Browse RUN QUALITY CONTROL

Weight Data Check

Station ID: 480037

Legend:

- Jan (Red solid line)
- Feb (Red dashed line)
- Mar (Red dash-dot line)
- Apr (Green solid line)
- May (Green dashed line)
- Jun (Green dash-dot line)
- Jul (Blue solid line)
- Aug (Blue dashed line)
- Sep (Blue dash-dot line)
- Oct (Black solid line)
- Nov (Black dashed line)
- Dec (Black dash-dot line)

Load Spectra

Axle Type

- Single
- Tandem
- Tridem
- Quad

Class

- Class 4
- Class 5
- Class 6
- Class 7
- Class 8
- Class 9
- Class 10
- Class 11
- Class 12
- Class 13
- All (4 to 13)

Gross Vehicle Weight
 Average Front Axle Weight
 Average Drive Tandem Axle Weight
 Load Spectra

Station	Accepted	Partial Accepted	Not Accepted	Year (Month) of Available Data
100019	300052	171651	100019	2002(Jan, Feb, Mar, Apr, May, Jun, J
10009	350019	420010	10009	2003(Jan, Feb, Mar, Apr, May, Jun, J
160058	350314	460006	160058	2004(Feb, Mar, Apr, May, Aug, Oct, N
160074	40432	480037	160074	2005(Jan, Feb, Mar, Apr, Jun, Jul, Au
161993	430038	71813	161993	
170049	600567	740035	170049	
170064	630008		170064	
171651			180002	
180002			181501	
181501			20006	
20006			20205	
20205			210033	
210033			220024	

None
 Bad Data
 Missing Data

QC Details

Station ID: 480037
 Gross Weight Criteria: Pass, 2 Peak
 Front Axle Criteria: Pass
 Drive Tandem Criteria: Pass
 Conclusion: Partial Accepted
 QC Method: Automatic

Relaxation Type

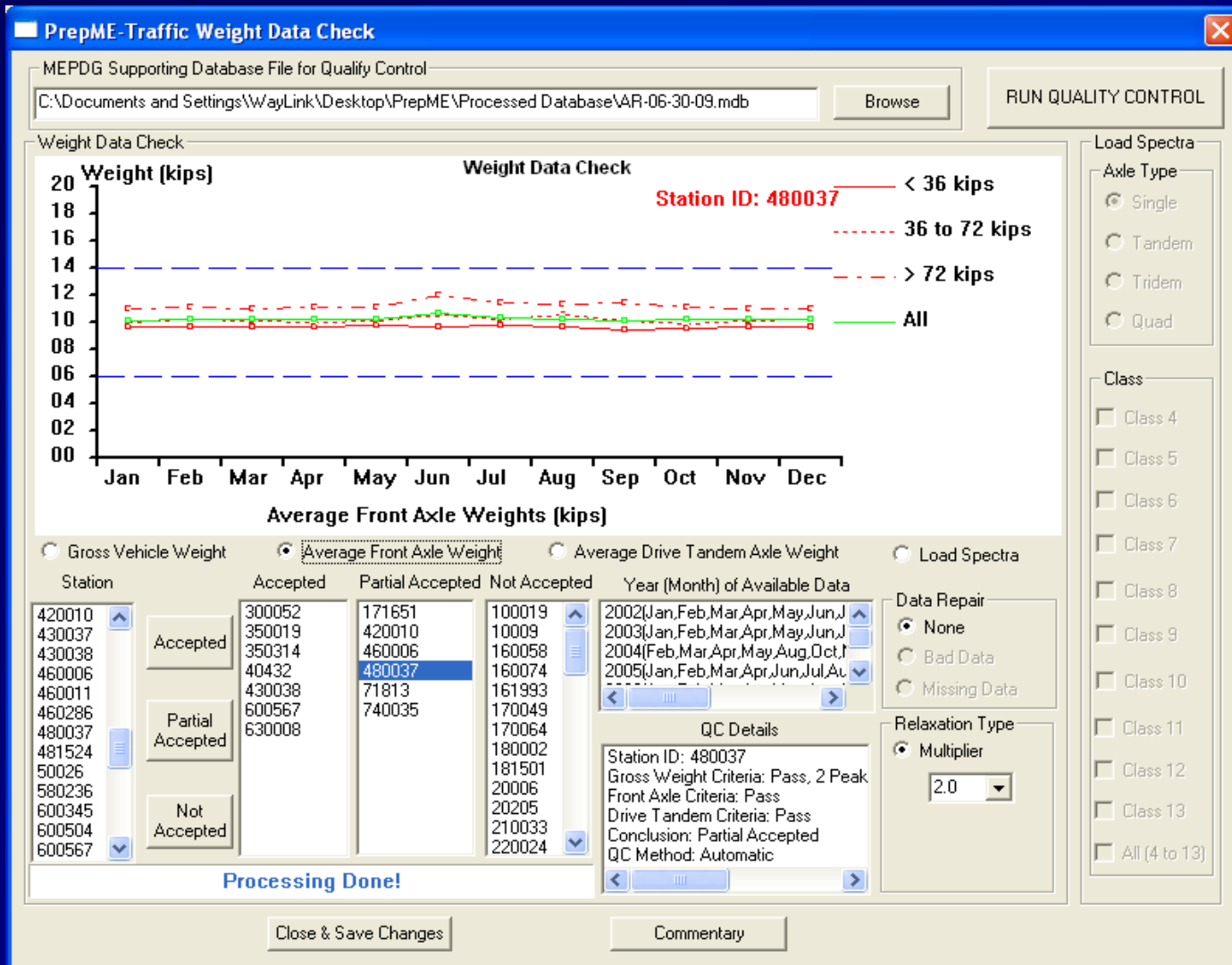
Multiplier

2.0

Processing Done!

Close & Save Changes Commentary

Weight Data Check Window



Weight Data Check Window

PrepME-Traffic Weight Data Check

MEPDG Supporting Database File for Quality Control
 C:\Documents and Settings\WayLink\Desktop\PrepME\Processed Database\AR-06-30-09.mdb Browse RUN QUALITY CONTROL

Weight Data Check

Weight Data Check
 Station ID: 480037

Weight (kips)

Average Drive Tandem Axle Weights (kips)

Gross Vehicle Weight
 Average Front Axle Weight
 Average Drive Tandem Axle Weight
 Load Spectra

Station	Accepted	Partial Accepted	Not Accepted	Year (Month) of Available Data
420010	300052	171651	100019	2002(Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec)
430037	350019	420010	10009	2003(Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec)
430038	350314	460006	160058	2004(Feb, Mar, Apr, May, Aug, Oct, Nov, Dec)
460006	40432	480037	160074	2005(Jan, Feb, Mar, Apr, Jun, Jul, Aug, Sep, Oct, Nov, Dec)
460011	430038	71813	161993	
460286	600567	740035	170049	
480037	630008		170064	
481524			180002	
50026			181501	
580236			20006	
600345			20205	
600504			210033	
600567			220024	

Class 4
 Class 5
 Class 6
 Class 7
 Class 8
 Class 9
 Class 10
 Class 11
 Class 12
 Class 13
 All (4 to 13)

Data Repair
 None
 Bad Data
 Missing Data

Relaxation Type
 Multiplier: 2.0

QC Details
 Station ID: 480037
 Gross Weight Criteria: Pass, 2 Peak
 Front Axle Criteria: Pass
 Drive Tandem Criteria: Pass
 Conclusion: Partial Accepted
 QC Method: Automatic

Processing Done!

Close & Save Changes Commentary

Weight Data Check Window

PrepME-Traffic Weight Data Check

MEPDG Supporting Database File for Quality Control
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Weight Data Check

Load Spectra
 Station ID: 480037

Gross Vehicle Weight
 Average Front Axle Weight
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460286	Partial Accepted	600567	740035	
480037		630008		
481524				
50026				
580236				
600345				
600504	Not Accepted			
600567				

QC Details
 Station ID: 480037
 Gross Weight Criteria: Pass, 2 Peak
 Front Axle Criteria: Pass
 Drive Tandem Criteria: Pass
 Conclusion: Partial Accepted
 QC Method: Automatic

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 Bad Data
 Missing Data

Relaxation Type
 Multiplier
 2.0

Load Spectra
 Axle Type
 Single
 Tandem
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Class
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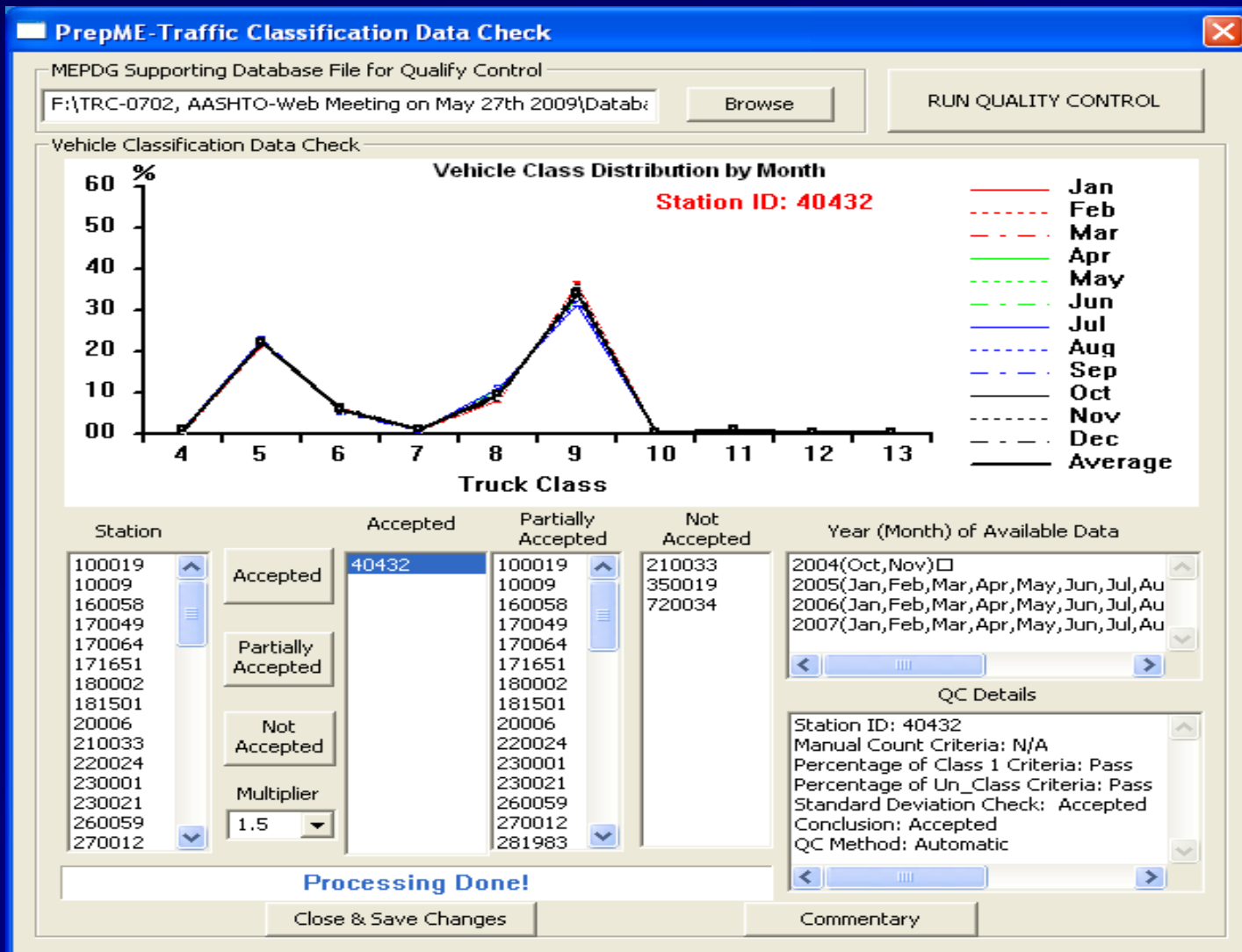
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Weight Data Check

■ Multipliers

- If No Multiplier: Few Stations Passed the Weight Data Check
- Need to Relax Requirements—Multipliers
- If multiplier=1.0, LTPP Weight Range, e.g.. $10,000 \pm 2,000$ lb;
- If Multiplier=2.0, For Example, the Range for Front Axle $10,000 \pm (2,000 \times 2.0)$ lb.

Vehicle Classification Data Check



Vehicle Classification Data Check

■ Multiplier

- Use Standard Deviation to Identify the Consistence of the Data
- If Multiplier=1.0, then 2 Standard Deviation.
- If Multiplier=1.5, then 3 Standard Deviation

Design Studies

- Comparing designs with “current practice”
 - Aid in identifying initial performance criteria
- Developing comprehensive database structure to integrate design, construction, performance/PMS data
 - More on this later...
- Developing “Design Handbook”

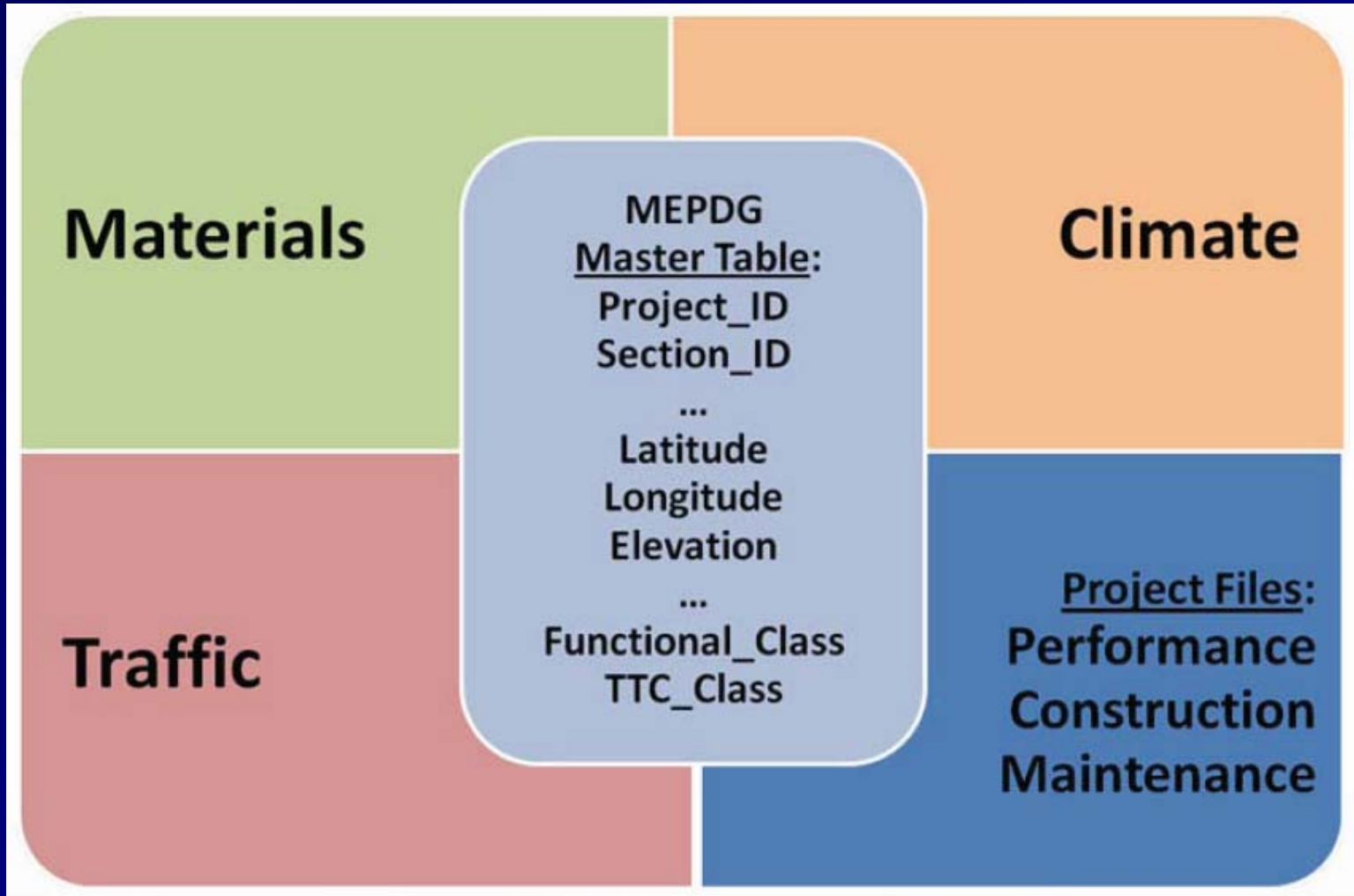
Local Calibration Efforts

- Potential “existing” section identification
 - LTPP sites within Arkansas
 - “Top 25” Superpave sites
 - Primarily modified binders
- Guidelines for data collection: new construction
 - Design
 - Construction
 - Performance monitoring

Database Software (PrepME) Development

- Significantly More Inputs Required
 - Order of magnitude “more” inputs than 1993 AASHTO
 - Many inputs not tracked (E^* , CTE, M_R)
- Data Sets Needed to be Pre-processed
 - Huge size of original data
 - Climate: Hourly, Multiple Parameters, > 10 Years
 - Traffic: 5 GB for AR between 2003-2005
 - Data Quality and Check: 10-25% WIM data are usable
- Local Calibration and Implementation Required (Long Term Process)

Database Structures



Software Features for Climate

■ Generate A Virtual Weather Station

- Input GPS Coordinates
- Interpolation
 - 6 Adjacent Weather Stations (MEPDG)
 - Based on Influencing Radius
- Prepare “*.icm” File for Specific Design

■ Prepare Water Table Depth

- Based on Database: Annually, or Seasonally
- User’s Input

■ Produce A Geo-Referenced Map

Database Design: Material Module

■ General Tables (4)

- Admix
- Gradation
- Shoulder
- M_R

■ AC Tables (7)

- Binder Conventional
- Brookfield
- DSR

- Mixture
- Dynamic Modulus
- Creep Compliance
- Indirect Tension Strength

PCC Tables (5)

- Joint
- Mixture
- Steel
- Strength
- Thermal

Database Design: Material Module

■ Others

- Stabilized Base (1)
- Subgrade (1)
- Unbound (1)
- Bedrock (1)

Pavement Performance Module

- Distress (MEPDG Required)
 - Based on LTPP Survey Manual
- FWD
 - FWD Equipment Information
 - Point to Point Dropping Data
- GPR
 - GPR Equipment Information
 - GPR Point Data
 - GPR Section Data
- Friction

Database Design: Construction Module

- As Built Construction Data
- Field Materials Sampling
- Construction QC/QA Testing
 - HMA
 - PCC
 - Stabilized Materials
 - Unbound Materials and Subgrade
- Tie to “Site Manager”

Database Design: Maintenance Module

■ PCC Pavement

- Crack Seal
- Full Depth Repair
- Partial-Depth Patching
- Joint Reseal

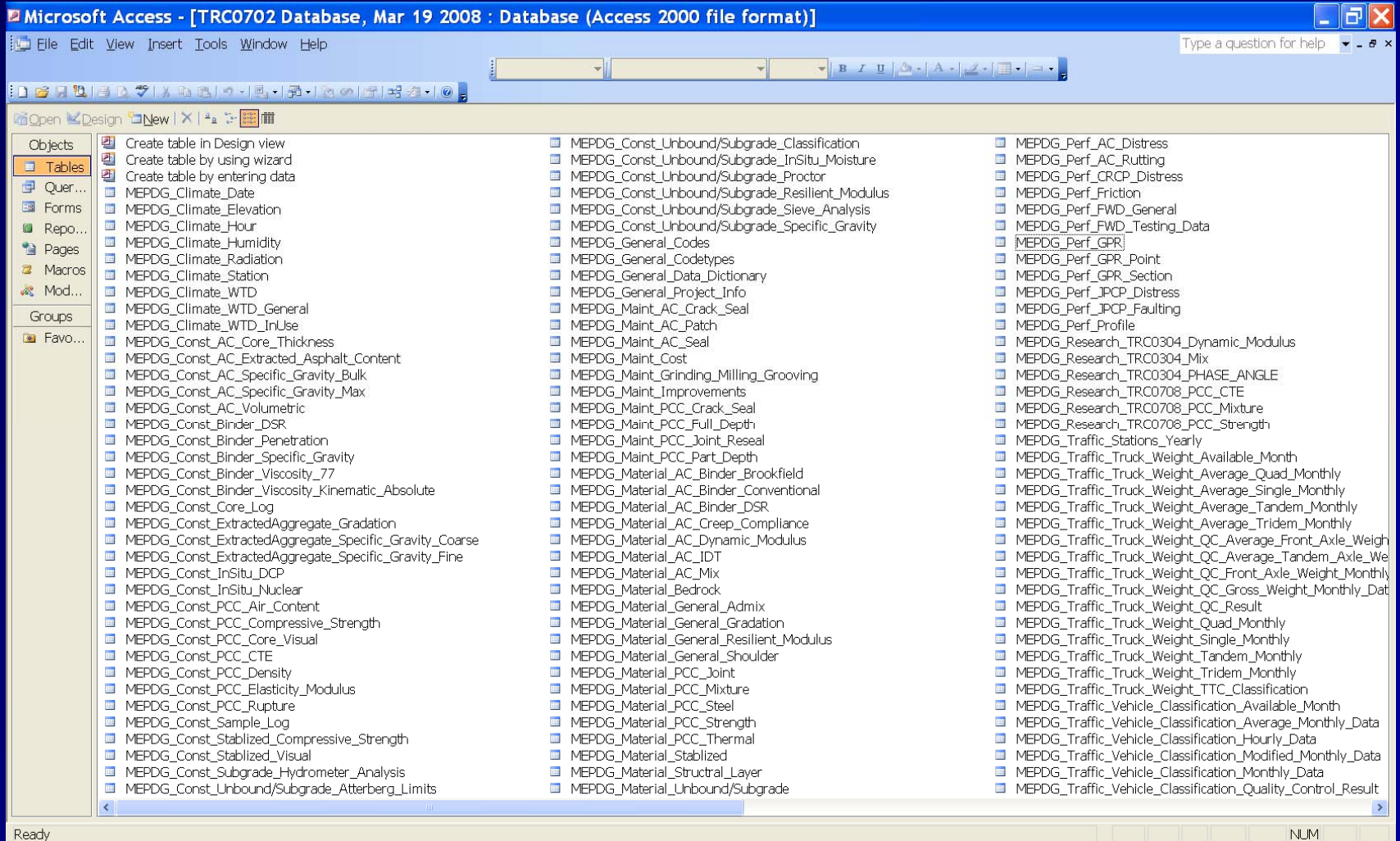
■ AC Pavement

- Crack Seal
- Patching
- Seal Coat

■ Others

- Grinding, Milling, Grooving
- Costs
- Improvements

Database Tables



Data Dictionary

Table 6 The structure of MEPDG_Climate_Hourly Table

Field Name	Data Type	Unit	Short Definition	Code Type	Field Key
WS_ID	VARCHAR2(7)		Unique identification number for a particular weather station		PK
WS_Date	Date		Date when climate data were collected		
WS_Hour	NUMBER(2,0)		Hour of day when climate data were collected		
Temperature	NUMBER(4,1)	deg F	Hourly ambient air temperature		
Precipitation	NUMBER(5,1)	mm	Hourly precipitation		
Wind_Speed	NUMBER(3,1)	m/s	Hourly mean wind speed		
Percent_Sunshine	NUMBER(3,1)	%	Hourly percent of sunshine		
Relative_Humidity	NUMBER(3,2)	%	Hourly relative humidity		

PrepME Capabilities

- Import Raw Data
- Traffic Data Check
- Interpolate Climate and Traffic Data
- Retrieve Material Data

Future Work

- Re-write the software for universal usage for any state and any WIM equipment
- Refine code development and debugging
- Refine database engine and visual/geo interface
- Allow manual processing of traffic data by user
- Enhance the importing speed using multi-thread programming techniques.
- Integrate with efforts in PMS, materials, and construction, et al
 - Add Resilient Modulus if the data are available
- Adapt database tables for SQL Express
- Add database security feature

Arkansas' Research Activities

■ “First Look”		
● Sensitivity Analyses	complete	\$176 ^k
■ Materials Characterization		
● Hot-mix asphalt	complete	\$330 ^k
● Portland cement concrete	complete	\$250 ^k
● Unbound materials	(“complete”)	????
■ Traffic Characterization	complete	\$ 81 ^k
■ Design Studies	ongoing	\$375 ^k
■ Database Development	}	\$300 ^k
■ Local Calibration Research		\$250 ^k

Total Research Commitment (to date): \$1670+^k

Arkansas' Bottom Line...

