Consideration of Preservation in Pavement Design and Analysis

June 27, 2016

Today's Presenters

- **Moderator**
  Judith Corley-Lay, NCDOT
- **Findings of NCHRP 1-48** David Peshkin, Applied Pavement Technology
- **Texas DOT Approach to Pavement Design**
  Magdy Mikhail, TexDOT
- **NC Review of Report 810** Judith Corley-Lay, NCDOT

NCHRP is...

A state-driven national program

- The state DOTs, through AASHTO's Standing Committee on Research...
  - Are core sponsors of NCHRP
  - Suggest research topics and select final projects
  - Help select investigators and guide their work through oversight panels

NCHRP delivers...

Practical, ready-to-use results

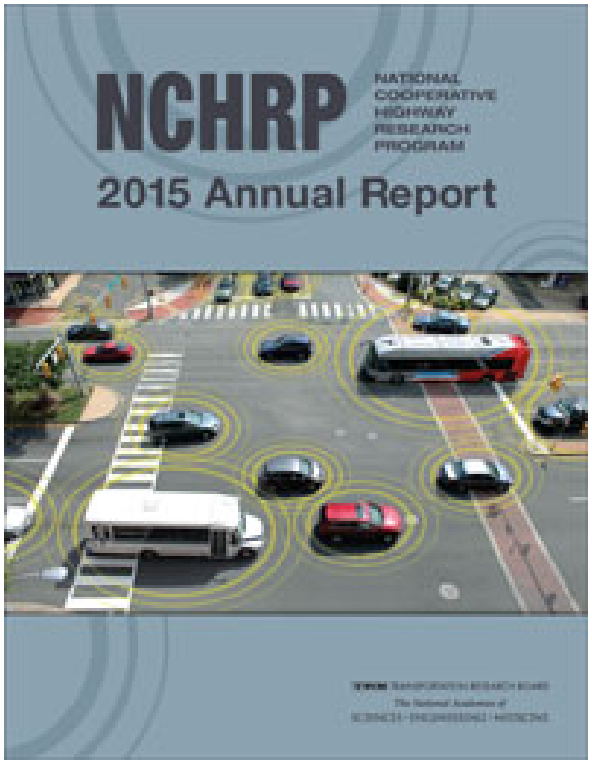
- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, manuals
- Can be directly applied across the spectrum of highway concerns: planning, design, construction, operation, maintenance, safety

A range of approaches and products

- Traditional NCHRP reports
- Syntheses of highway practice
- IDEA Program
- Domestic Scan Program
- Quick-Response Research for AASHTO
- Other products to foster implementation:
  - *Research Results Digests*
  - *Legal Research Digests*
  - *Web-Only Documents and CD-ROMs*

NCHRP Webinar Series

- Part of TRB's larger webinar program
- Opportunity to interact with investigators and apply research findings.



Today's First Presenter

- **Findings of NCHRP 1-48**

David Peshkin,

Applied Pavement Technology

Consideration of Preservation in Pavement Design and Analysis Procedures

NCHRP Project 1-48 / NCHRP Report 810

Presentation Summary

- Project overview
- Information sources for state of practice
  - Literature
  - Interviews
- Evaluation of test sections used in MEPDG
- Recommended procedures for incorporating pavement preservation into the MEPDG and associated steps

Project Overview

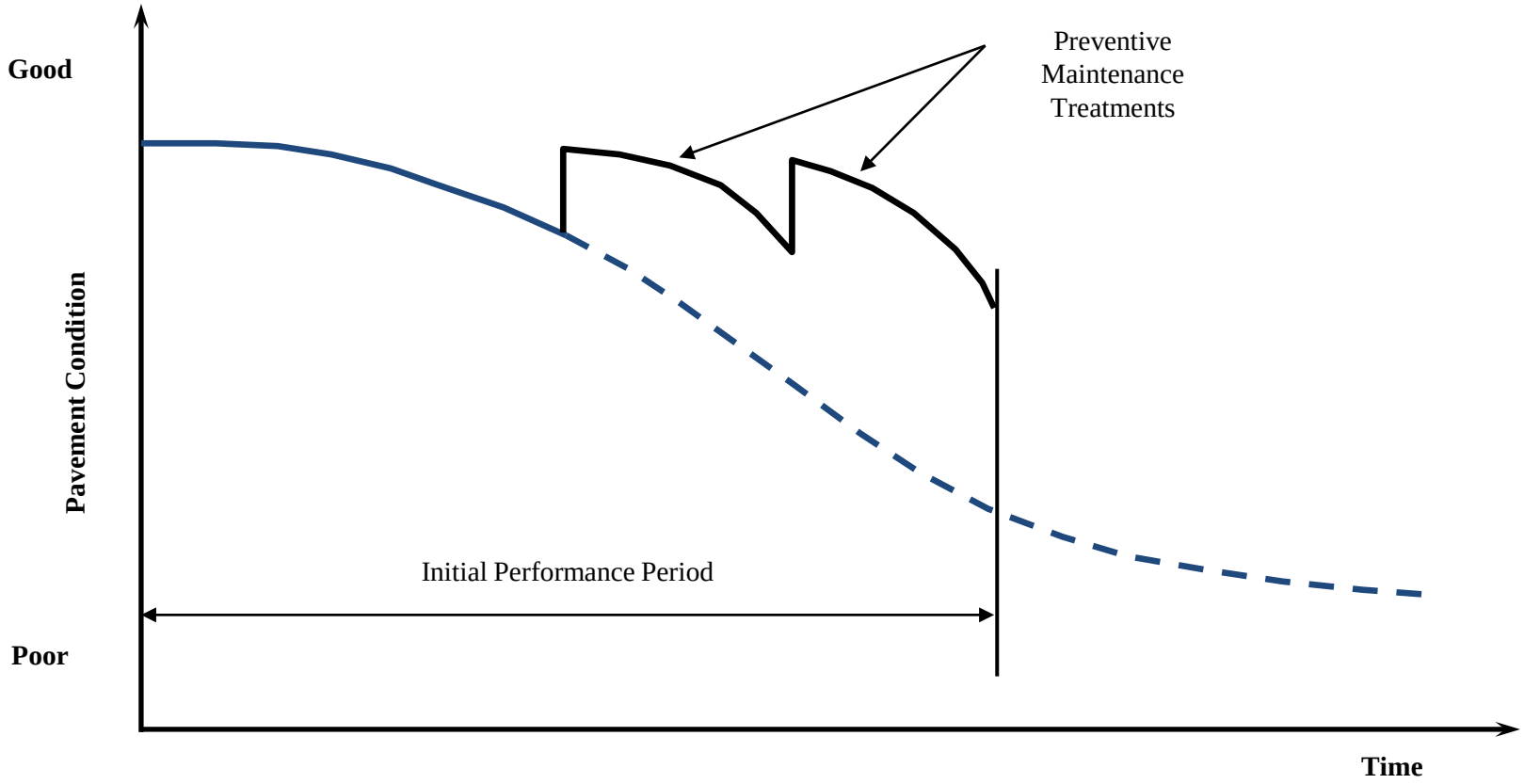
Background—

(1) The MEPDG is increasingly being used by agencies as the pavement design and analysis tool. (2) Most agencies have some sort of preservation program. (3) MEPDG models do not consider the effects of preservation.

Initial Project Objective—

Develop procedures for incorporating pavement preservation treatments into the MEPDG process.

Underlying Concept



Literature Review

Sources

NCHRP/TRB
AASHTO
FHWA
National research organizations
Preservation organizations
Industry organizations

Pavement preservation performance
Effects of preservation on pavement performance

MEPDG models
Agency calibration efforts

Literature Review Topics

- Techniques for analyzing performance of pavement preservation treatments
- MEPDG performance prediction models
- MEPDG evaluation and implementation activities, including local calibration

Interviews

Included SHAs and selected industry representatives

- Purpose: gather information from agencies with progressive preservation and MEPDG experience
- SHAs: Arizona, California, Indiana, Kansas, Maryland, Minnesota, Missouri, New Jersey, North Carolina, Ohio, Texas, Utah, Virginia, Washington
- Industries: NCPP, ACPA, ISSA, NAPA, AEMA

Interview Results—SHAs

- Preservation practices vary widely: half of respondents have dedicated funding, most programs are decentralized, little in common regarding treatment use, tracking performance inconsistent
- MEPDG: two current users, two doing side-by-sides, the rest in various stages of implementation
- Incorporating preservation: different ideas about how to do this, but no one is actually doing it; CalME includes the ability to do it (still prototype) [two approaches: reset certain distresses at time of treatment or adjust future material properties]

Interview Results—Industry

- Preservation: all have strong emphasis on preservation; little objective data on pavement life extension
- MEPDG: NCPP, AEMA, ISSA not very familiar; NAPA, ACPA very familiar, but from perspective of design, not preservation
- PP and the MEPDG: NAPA, ACPA thought it was a good idea, but would need an LTPP-type experiment to implement

Evaluation of MEPDG Test Sections—Overview

Wanted to answer the question: Did pavements used to develop or verify MEPDG models benefit from preservation?

- Identify pavement sections
- Extract maintenance history from LTPP database and other sources
- Organize information in tables
- Determine whether treatments may have affected MEPDG models

Evaluation of MEPDG Test Sections—Findings

- Table 3 (p. 12) summarizes sections used to develop and calibrate MEPDG performance prediction models
- Table 4 (p. 13) summarizes potential influence of preservation on performance of sections and MEPDG model development and calibration

Evaluation of MEPDG Test Sections—Findings (continued)

- Flexible pavement models (10): 2 NA; range from 2 to 67 percent [crack sealing, fog, slurry, seal coats]
- Rigid pavement models (9): 4 NA; range from 7 to 23 percent [joint resealing, crack sealing, PDR, FDR, a few instances of grinding/grooving]

Transition from Phase I to Phase II

- Phase I outcome: three approaches to consider effects of preservation in the MEPDG
  - Develop pavement preservation response models
  - Calibrate existing models for effect of preservation
  - Modify material properties to account for preservation effects

Identified data to fully develop these approaches and their availability within SHAs. Conclusion – sufficient data not readily available.

Phase II: Describe/Illustrate Approaches

1. Response models which consider effects of preservation in the MEPDG procedures (chapter 4).
2. Calibration of MEPDG models to account for preservation (chapter 5).
3. Modify material and pavement structural properties in MEPDG models to account for preservation effects (chapter 6).

- Assess feasibility
- Provide example

Approach 1—Response Models

- Create experimental matrix and construct test sections
- Test sections dictated by variables of interest to agency
- Include controls (based on MEPDG design)

Response Models Steps

- Pavement preservation treatment and strategy selection
- Experimental design
- Construct test sections/sites
- Monitor performance
- Develop performance models
- Calibrate/validate models

Example Experimental Matrix

Climate Zone	Preservation Treatment	Flexible Pavement		
		Conventional HMA	Full-Depth HMA	
		Low-Volume State Routes	Moderate Volume US and State Routes	Interstate and Freeway Routes
Wet, hard freeze, spring thaw	(0) Untreated control	Site 1	Site 2	Site 3 (chip seals excluded)
	(1a) Chip seal @ Year 4			
	(1b) Chip seal @ Year 5			
	(1c) Chip seal @ Year 6			
	(1d) Chip seal @ Year 7			
	(2a) Microsurface @ Year 4			
	(2b) Microsurface @ Year 4			
	(2c) Microsurface @ Year 4			
	(2d) Microsurface @ Year 4			
	(3a) Thin HMA Overlay @ Year 4			
	(3b) Thin HMA Overlay @ Year 4			
	(3c) Thin HMA Overlay @ Year 4			

Approach 2—Calibrate MEPDG Models

- Systematic process to eliminate bias and minimize residual errors between observed or measured real world results and predicted (model) results
- Assumes existing models do not, or don’t adequately, account for preservation

Calibrate MEPDG Model Steps[1]

1. Selected hierarchical input level
2. Develop experimental plan
3. Estimate sample size for specific models
4. Select roadway segments
5. Extract/evaluate distress and project data
6. Conduct field and forensic studies

[1] From AASHTO *Guide for Local Calibration*

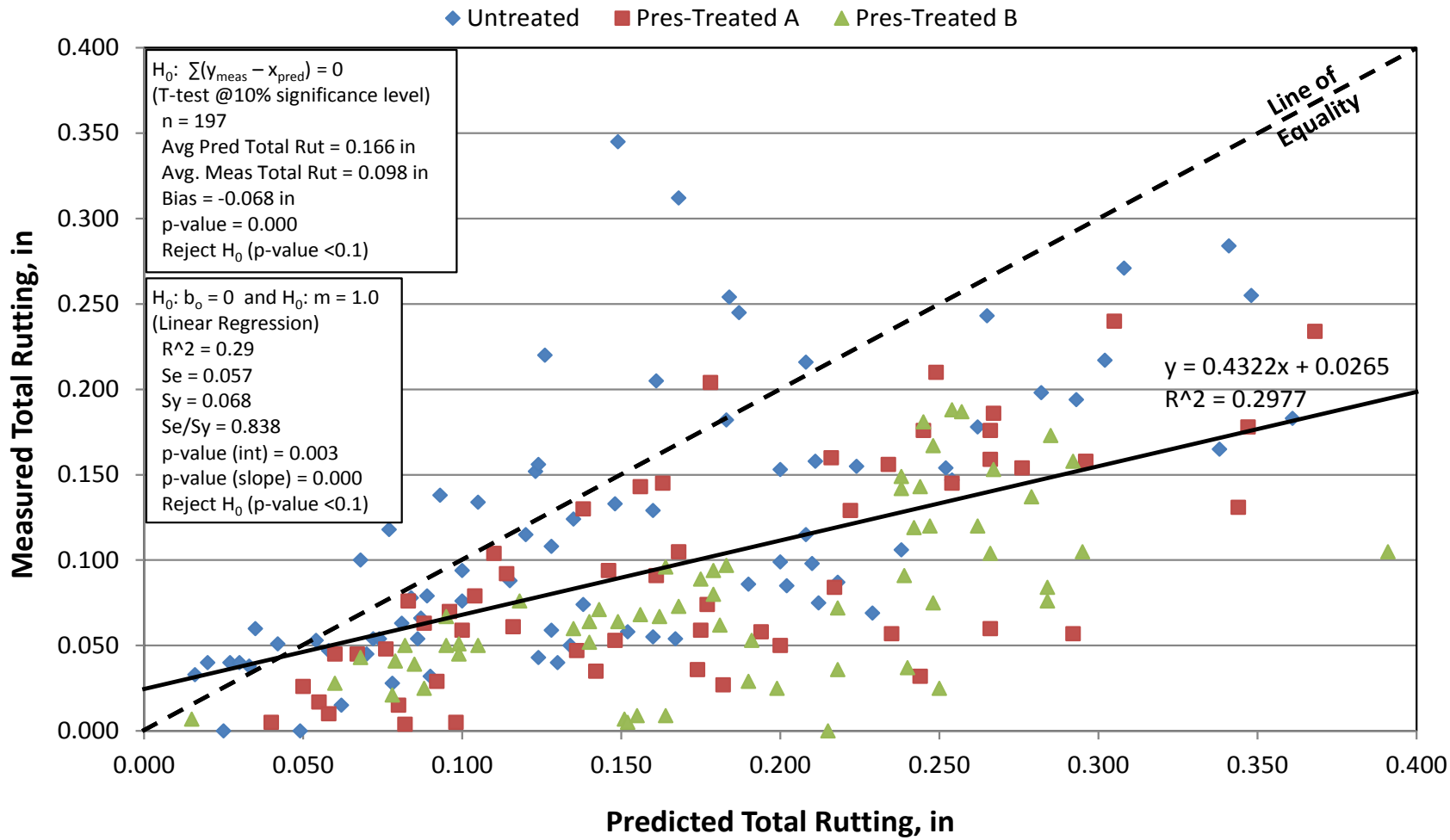
Calibrate MEPDG Model Steps (continued)

7. Assess local bias
8. Eliminate local bias of distress, IRI
9. Assess standard error of estimate (SEE)
10. Reduce SEE
11. Interpret results/evaluate adequacy of calibration parameters

Approach 3—Modify Material and Structural Properties

- “Corrected” distress (or life) to reflect effects of preservation
- Correction consists of altering MEPDG outputs
- Requires knowledge, understanding, or ability to estimate effect of preservation treatments or strategies on predicted distresses

Model Modification Example



Steps to Modify Properties in MEPDG Models

1. Identify basic pavement structure and preservation treatment type
2. Identify preservation treatment timing
3. Identify baseline material properties of pavement structure and treatment
4. Quantify treatment effect on thickness
5. Identify effect on existing layer material properties and on moisture/thermal properties

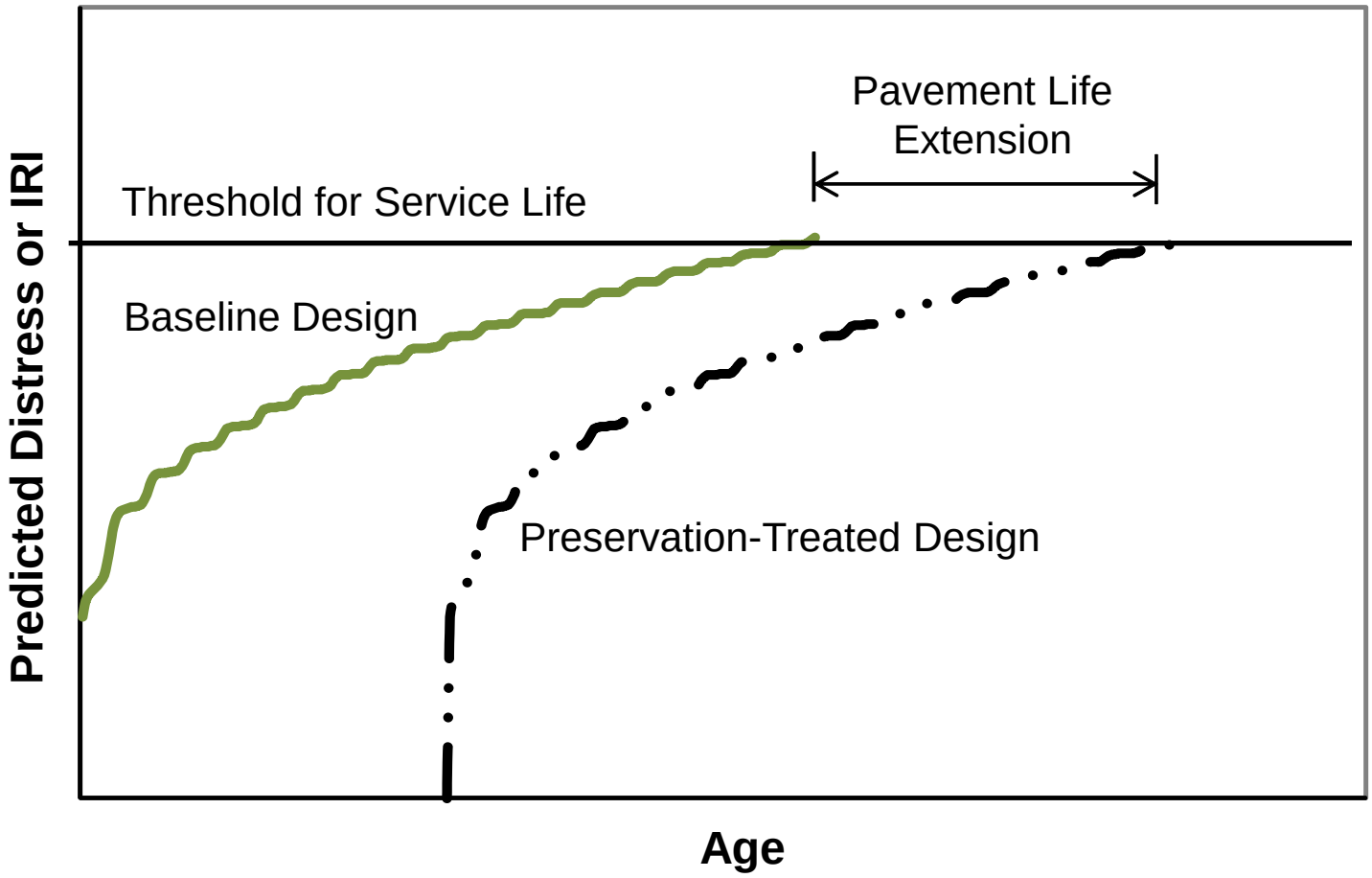
Steps to Modify Properties in MEPDG Models (continued)

6. Identify treatment effect on pavement performance
7. Establish MEPDG model coefficients
8. Perform base pavement ME design analysis
9. Perform ME design analysis for preservation-treated design

NCHRP 1-48 Outcomes and Recommendations

- Growing experience with use of preservation
- Lack of agency documentation of impacts of preservation
- Recognition that preservation has ability to extend service life and delay need for subsequent structural treatments
- Acknowledgment that preservation is not a structural enhancement and MEPDG is a structural design process
- More data needed to support implementation of identified approaches.

Example Effect of Preservation



Questions and Discussion

applied pavement
TECHNOLOGY

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Texas Department of transportation approach to pavement design

Table of Contents

Flexible Pavement Design in Texas

- Decentralized design
  - Most designs done in-house, usually in Area Offices (100+)
  - Construction Division provides support and training
- Texas Network
  - Over 50% of network very thin surfaced asphalt pavements
  - Range of climates and soil support conditions
- Materials Information
  - Thickness designs completed 1 – 2 years before materials selection
  - Designs currently based on spec item number

Flexible Pavement Design in Texas

- Traffic Data
  - Based on 20 Year 18 Kip ESAL's
  - Extensive Axle load Spectra data not available

- Implementation Status
  - Original FPS developed in the 1970's
  - Current system implemented mid 1990's
  - Training schools taught in-house and with University support
  - Experienced designers comfortable with results

Design Process

- Project Selection
  - PMIS
  - 4-year Plan
  - Key Staff recommendations
- Request Traffic Data
- Evaluation of Existing Structure
  - Records
  - Site visit
  - NDT
  - Sampling

Design Process

Design

- On Line Pavement Design Guide
- District SOP
- Pavement Design Concept Conference
- FPS 21
- 1993 AASHTO (DarWin 3.1)
- TxCRCP-ME

Materials Selection

- Standard & Special Specifications and Special Provisions
- Special Guidelines/SOP

Design Review

Project Selection

- PMIS
  - Set of automated tools to help identify sections in most need of improvement
  - Present condition
  - Multi-year trends
  - Predictions of future performance
- Staff Recommendations
  - Maintenance and Area Engineers
  - District Pavement Engineer
  - Planning and Development

Request Traffic Data

- TP&P is the TxDOT “sole source”
- TP&P manages statewide traffic data collection (WIM, Classification, Counts)
- Critical Traffic input parameters include:
  - Beg & End ADT
  - % Trucks in the ADT
  - ATHWLD
  - Cumulative ESALs (20 or 30 yr)

Design Traffic Report

TRAFFIC ANALYSIS FOR HIGHWAY DESIGN

Houston District

November 12, 2008

Description of Location	Average Daily Traffic 2011	Average Daily Traffic 2031	Base Year Dir Dist %	Base Year K Factor	Base Year Percent Trucks ADT	Base Year Percent Trucks DHV	ATHWLD	Percent Tandem Axles in ATHWLD	Total Number of Equivalent 18k Single Axle Load Applications One Direction Expected for a 20 Year Period (2011 to 2031) Flexible Pavement	S N	Rigid Pavement	SLAB
Loop 494												
At White Oak Creek	10,700	15,300	54 - 46	12.2	13.3	8.8	13,300	60	5,173,000	3	6,839,000	8"
Montgomery County												

Description of Location	Average Daily Traffic 2011	Average Daily Traffic 2041	Base Year Dir Dist %	Base Year K Factor	Base Year Percent Trucks ADT	Base Year Percent Trucks DHV	ATHWLD	Percent Tandem Axles in ATHWLD	Total Number of Equivalent 18k Single Axle Load Applications One Direction Expected for a 30 Year Period (2011 to 2041) Flexible Pavement	S N	Rigid Pavement	SLAB
Loop 494												
At White Oak Creek	10,700	17,300	54 - 46	12.2	13.3	8.8	13,400	60	8,356,000	3	11,048,000	8"
Montgomery County												

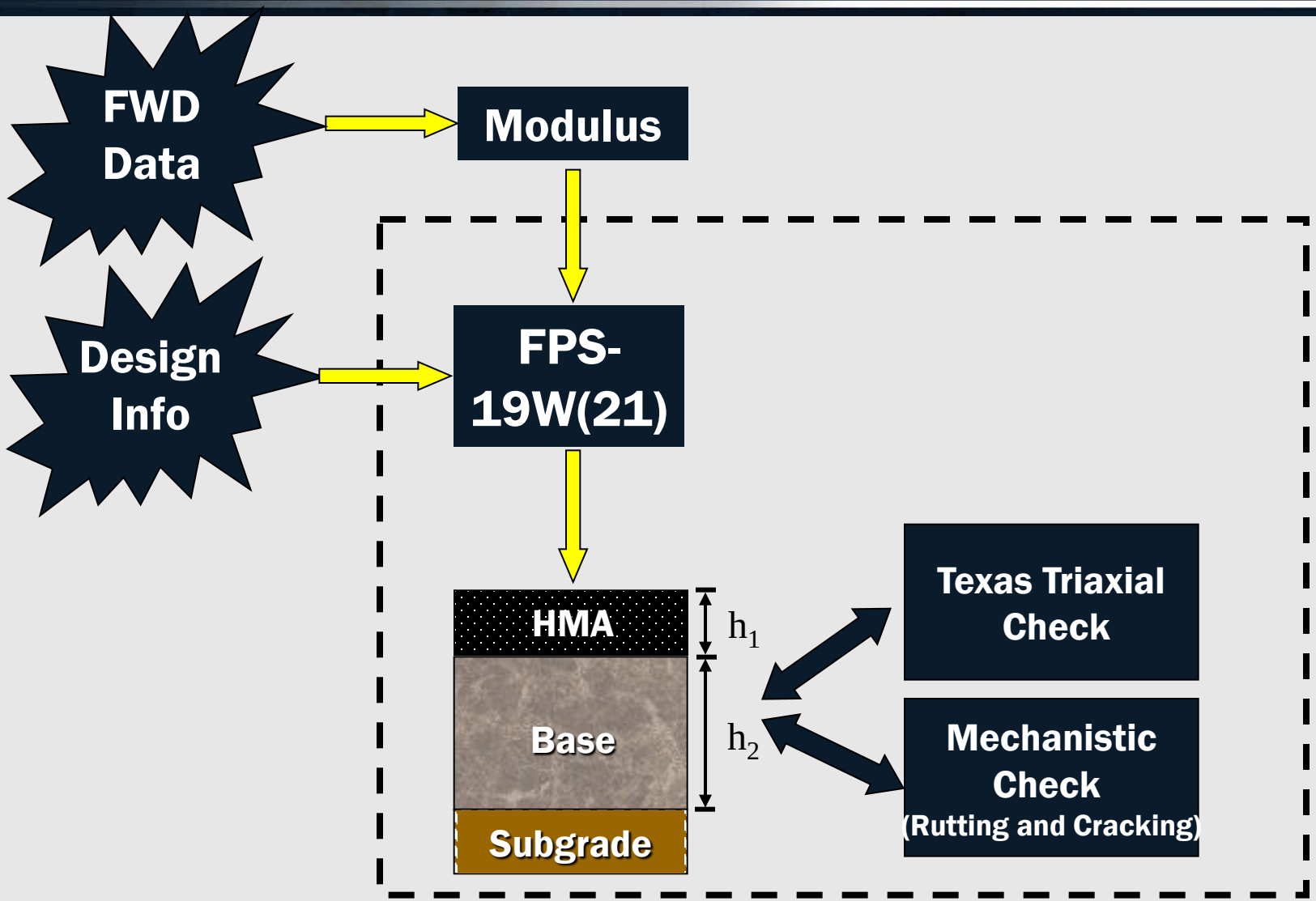
Evaluation

- Records
  - As-built drawings/plans
  - Maintenance
  - Soils Maps
- Site Visit
  - Drainage issues
  - Cross slope/crown
  - ROW issues
  - Distress Survey

Evaluation (cont.)

- NDT
  - Rut/Ride
  - Skid
  - Deflection
  - GPR
  - DCP
- Sampling
  - HMA Cores
  - Soil Borings
  - Auger/Trench (FDR samples)

Pavement Design



Pavement Design

Pavement Properties

FPS 21

- Traffic
- Reliability
- Serviceability

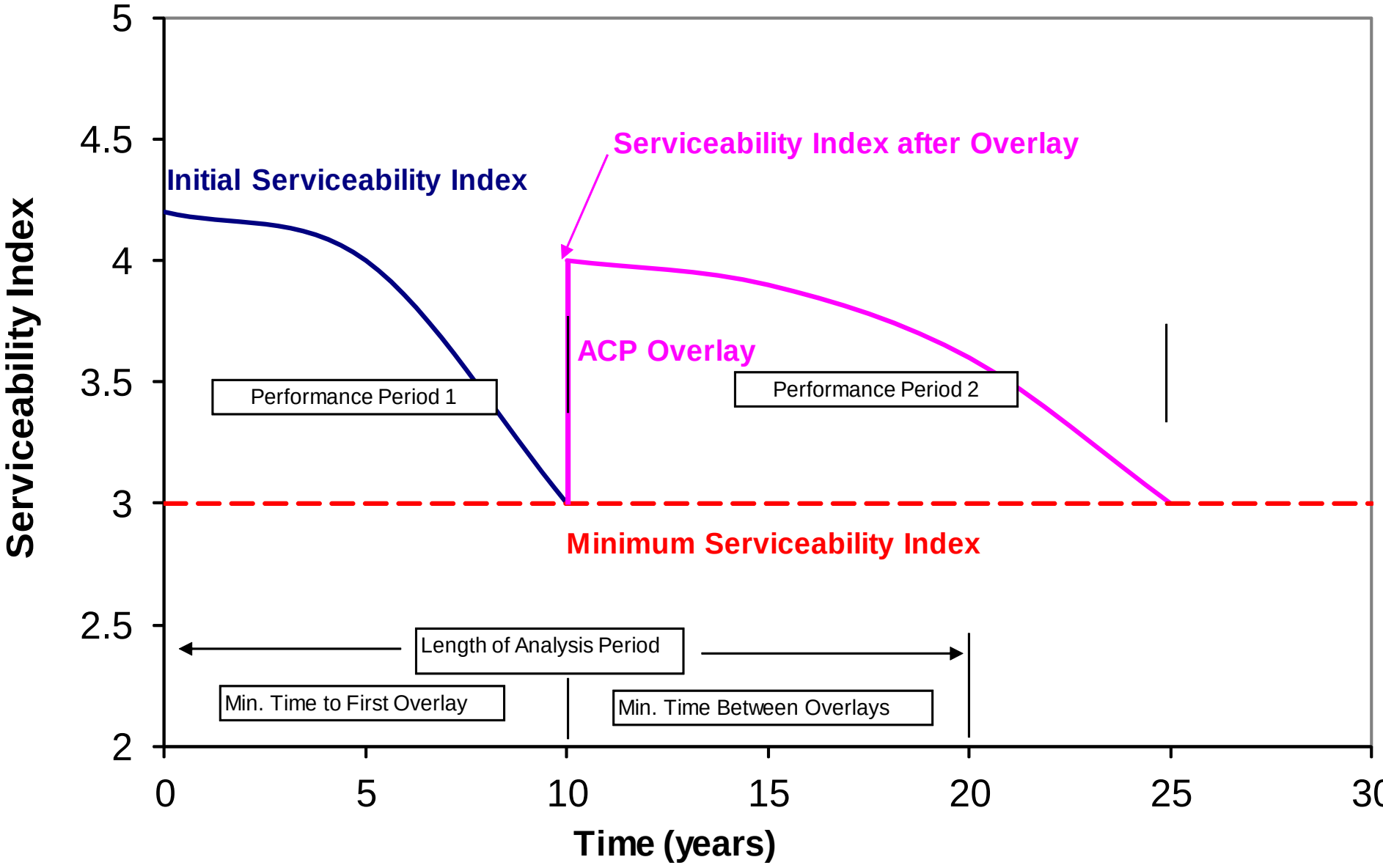
Design Alternatives

- District SOP
- Material Testing
- Life-cycle Cost
- Initial Construction Funding Available
- User Delay

Consider Constructability and material characteristics

– Does the structure make sense ??

Performance Curve



The Design Report – When is One Required?

- **A Design Report is Required For:**
  - **Structural changes > 500-ft long, including:**
    - **New Location Projects**
    - **Reconstruction Projects**
    - **Rehabilitation (3R) Projects**
    - **Unbonded Concrete Overlays**
  - **Special Cases:**
    - **Document the Criteria and Rationale for the Strategy Selected**
      - **Bridge Approaches**
      - **Detours**
      - **Pavement Widening**
      - **HMA Overlays of Rigid Pavements**
      - **Bonded Rigid Overlays of Rigid Pavement**
      - **Thin Whitetopping of Flexible Pavement**

The Design Report – Steps for Approval

- **Key District Players Agree on General Pavement Format: Design Concept Conference**
- **Technical Review/Approval: District Pavement Engineer (License #)**
- **Final Approval: District Engineer w/Signature and Date (exception only for Metro Districts, value < $20M).**
- **Qualifier statement: "This document is released for the purpose of interim review and is not intended for bidding, construction, or permitting purposes."**

FPS 21 – Design Types

1
- Seal
- Flex Base
- Subgrade

2
- AC
- Flex Base
- Subgrade

3
- AC
- ASB
- Subgrade

4
- AC
- ASB
- Flex Base
- Subgrade

5
- AC
- Flex Base
- Stab. SG
- Subgrade

6
- Overlay
- AC
- Base
- Subgrade

User-defined; 4 to 7 Layers

- HMA Base
- RBL
- Stab. SG
- Subgrade

8

Use Existing Input File

FPS 21 Strengths and Shortcomings

Does:

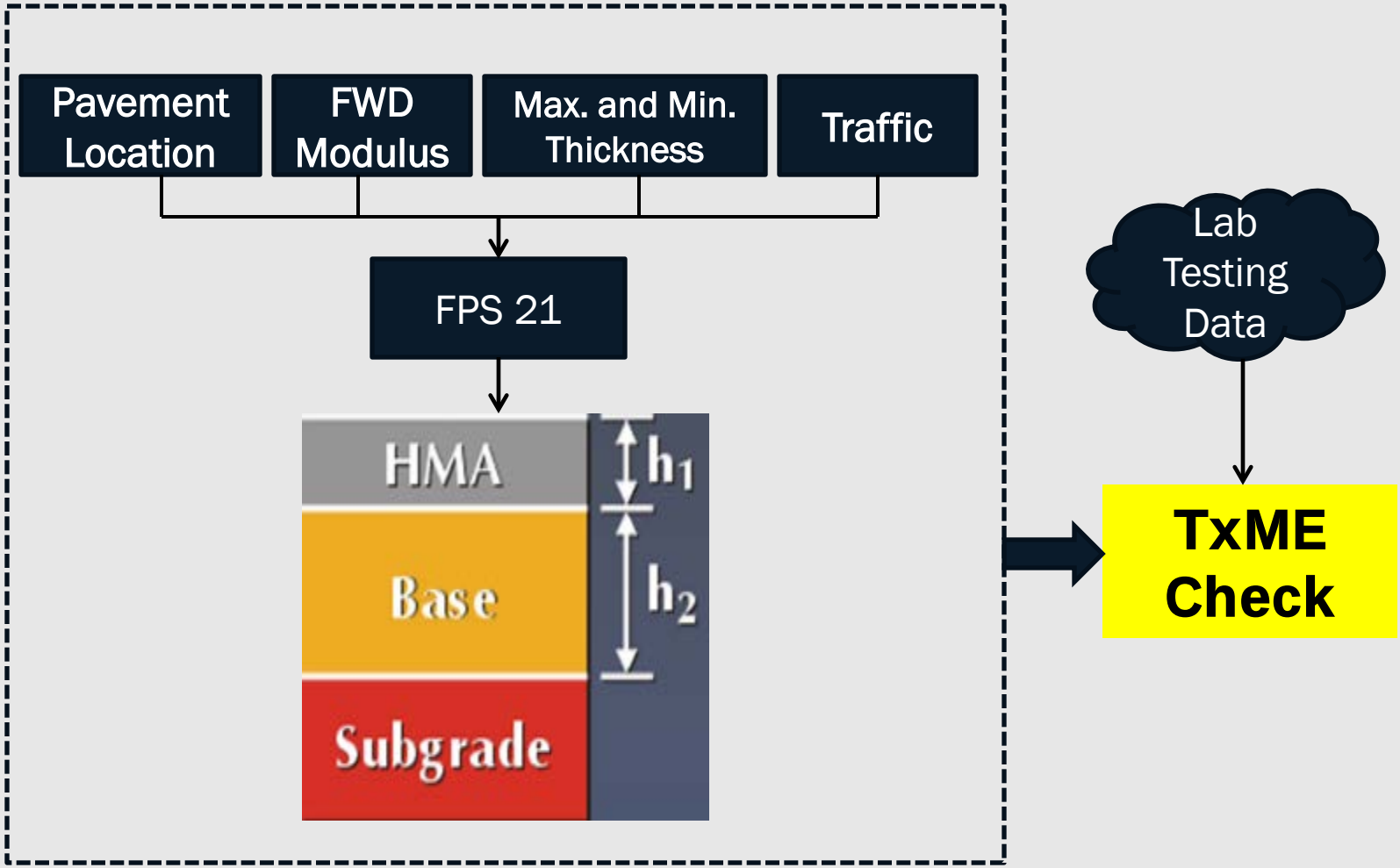
- Flexible Base Pavements
- Asphalt Stabilized Base Pavements
- Lightly Stabilized Base Pavements (<3% Stabilizer)
- Perpetual Pavements
- Overlay Thickness

Does Not Do:

- Heavily Stabilized Pavements
- Concrete
- Overlay on CTB or Concrete

Transition to M-E design

Future Direction



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Questions

An Agency look at Considering Preservation in Pavement Design

Judith Corley-Lay

June 27, 2016

Outline of Presentation

- Our review of Response Model approach
- Our review of Calibrating MEPDG models
- Our review of Modified Material and Structural properties in ME models
- So what can we do?

Response Models that consider effects of preservation.

Test Section Approach

- Would need test sections for full depth asphalt and aggregate base pavements.
- Regular aggregate and lightweight aggregate.
- Control section, single chip seal and double seal.
- With and without polymer modifications.

Test sections

- Also need to include thin lift overlays.
- 3 climatic zones
- 2-3 traffic levels
- Monitor for 7-10 years or longer
- Replicates???

Test Section issues

- Experimental design dictates treating pavements at different points in time. Difficult to maintain this schedule over time.
- Would also need to conduct similar process for rigid pavement preservation, although our history here is short.

Calibrating ME models to Account for Preservation

Local Calibration

- Goal is to eliminate bias and make predicted distresses better match measured distresses.
- May reduce scatter in the data
- Each distress has one or more coefficients that are modified during local calibration.

Local Calibration approach

- Must cover a range of distress levels for each distress type.
- Large number of test sections is required.
- Need 10 years of performance data- 4 years before treatment and 5 years after.
- May need field investigation to fill missing data.

Using modified material and structural properties in ME models

Must identify exact impact of each preservation treatment

- For example, microsurfacing may reduce rutting by ½ inch.
- Rejuvenator or fog seal will reduce the modulus of the asphalt surface. How long will the reduction be maintained?
- Treatment may change the pavement structure: milling or diamond grinding.
- Treatment may change moisture/temp profile.

Drawback

- “A major drawback to this approach is the complexity of accurately defining the changes in properties resulting from the application of different preservation treatments at different times during the life of the pavement.”
- Some of this could be done through national research.

So what CAN we do?

NCDOT current view…

- We have performed 3 cycles of automated data collection that provide the necessary level of data accuracy and consistency.
- We do not yet have enough data to apply approach 2 (local calibration), but that approach will be feasible for us.
- We can identify test sections in preparation for using this approach.

Current view…

- NCDOT will be performing a local calibration in the coming six months.
- Since we have a long standing preservation program for flexible pavements, this local calibration may satisfy some of the method 2 requirements.

Conclusions

Consideration of Preservation in ME design

- Method 1 required years of consistency in applying treatments on a schedule.
- Method 2 requires local calibration, which NCDOT plans to do in the next 6 months.
- Method 3 requires carefully defining impacts of each preservation treatment on material properties, structure, distress levels, and moisture/temperature regime.

My contact information: jlay@ncdot.gov

Thank you for your attention.

QUESTIONS?