Four Decades of Pavement Management: What We've Learned, Forgotten, or Never Knew

By

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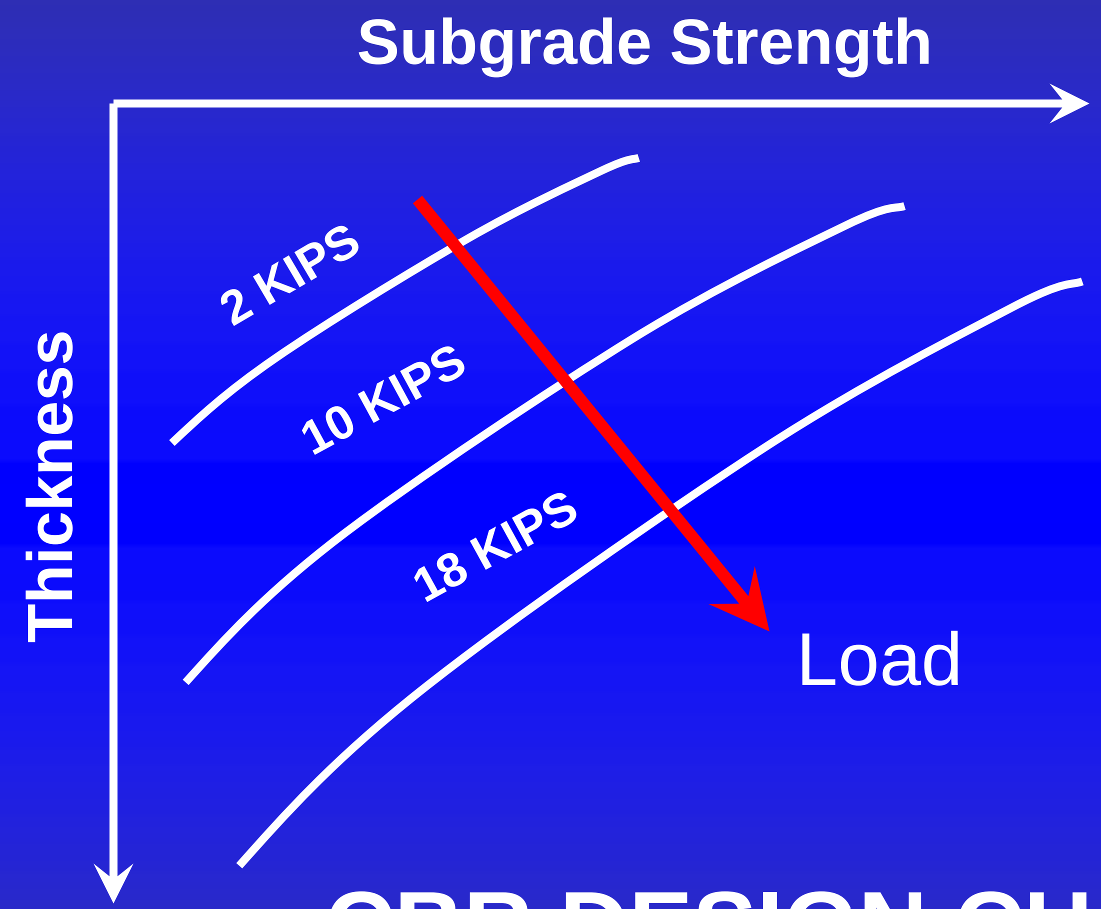
“Those that fail to learn from history, are doomed to repeat it.”

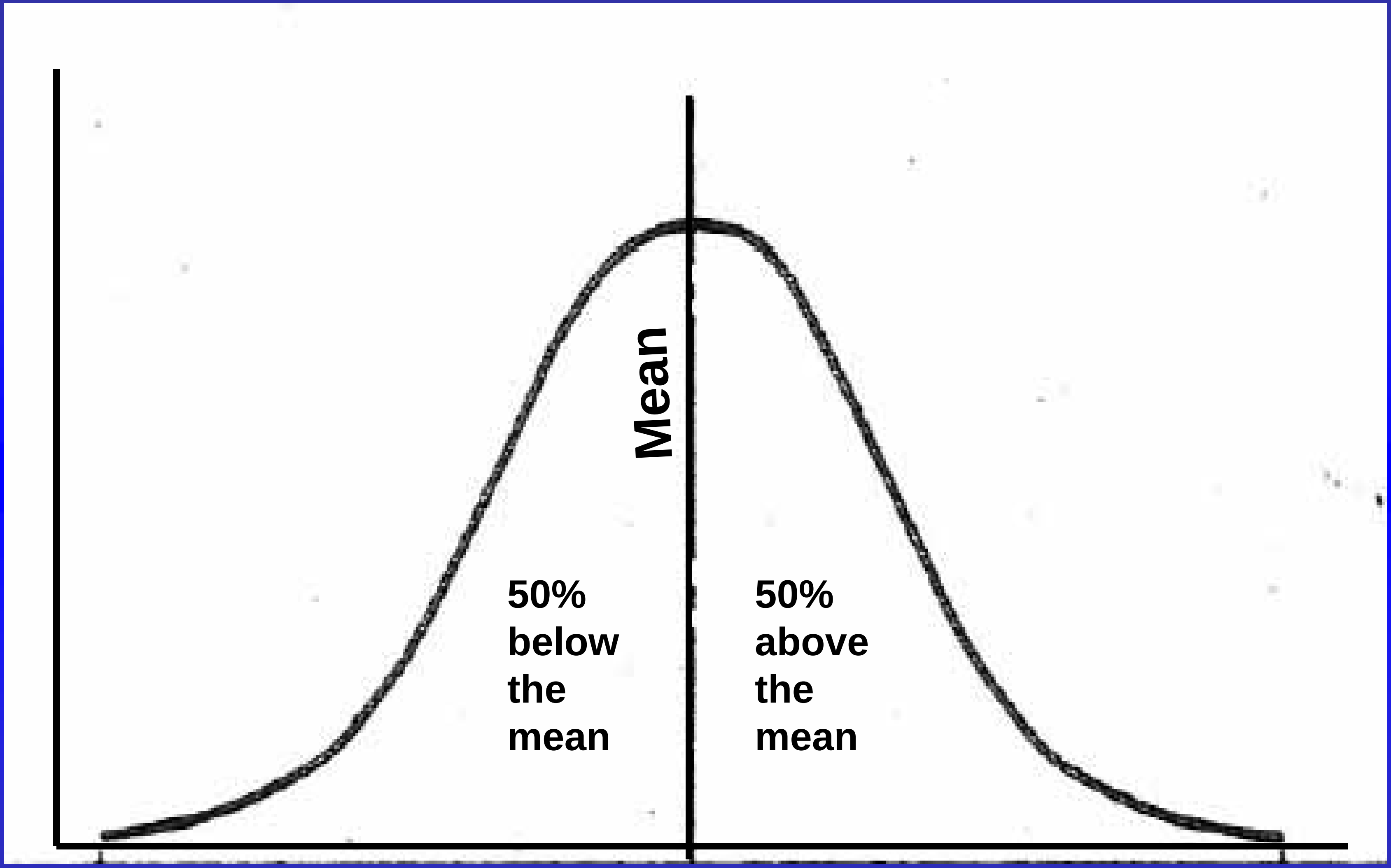
Winston Churchill

- Yoder, E. J., and M. W. Witczak, *Principles of Pavement Design*, John Wiley and Sons, 1975.
- Haas, Ralph, W. R. Hudson, *Pavement Management Systems.* McGraw-Hill. 1978
- Haas, Ralph, W. R. Hudson, and J. P. Zaniewski, *Modern Pavement Management*, Krieger Publishing Company, Malibar, FL 1994.
- Hudson, W. R., R. Haas, and W. Uddin, *Infrastructure Management Principles,* McGraw-Hill, August 1997.



CBR DESIGN CHART

The area under the mean or under any specific value is Zero



Measured Value Such as Modulus →

Road Test MD-1

PCC Pavements 1950

WASHO Road Test

Asphalt Pavements 1954-56

AASHO Road Test

Both Pavement Types 1958-61

WHERE WERE WE BEFORE THE AASHO ROAD TEST in 1956?

1. **CBR – Standard method of flexible pavement design (load, subgrade strength, total pavement thickness**

2. **WASHO Road Test (1954) suggested that thicker surface produced longer life**

3. **There was no accepted definition of pavement failure or performance**

4. **The Interstate Highway Program was just beginning**

5. **Available computer power was not adequate for rapid calculation of layered stresses.**

1. **PCA method based on modified Westergaard Theory was the standard for Rigid Pavement Design.**

2. **Subgrade and subbase pumping under heavy loads was a major problem**

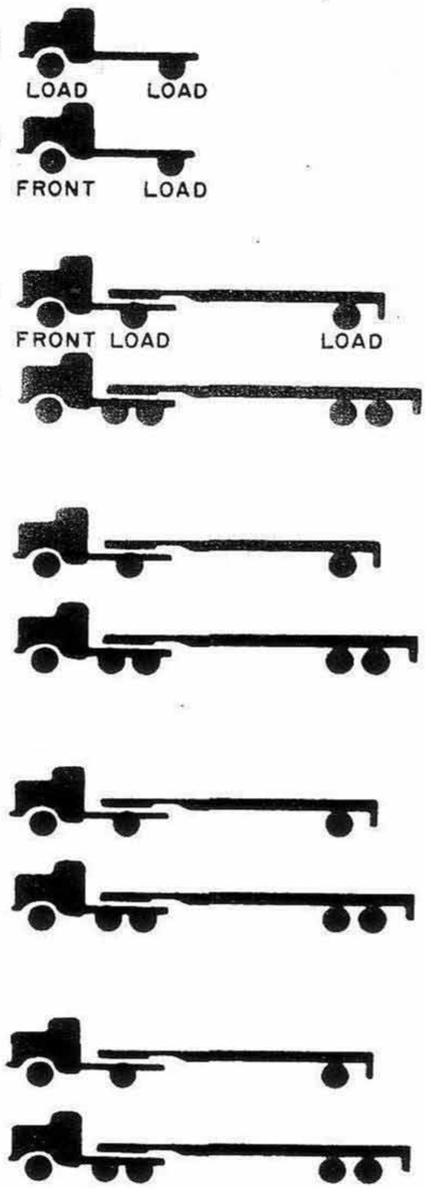
3. **Corner cracking was a major failure mode**

4. **Using dowels for load transfer with dowels was not yet an accepted practice**

TABLE 2

Pavement Designs, Rigid Tangents

Reinf.	Surfacing \ Subbase \ Loop	1		2			3				4				5				6			
		0	6	0	3	6	0	3	6	9	0	3	6	9	0	3	6	9	0	3	6	9
REINFORCED	2 1/2	x	x	x	x	x																
	3 1/2			x	x	x		x	x	x												
	5	x	x	x	x	x		x	x	x		x	x	x								
	6 1/2							x	x	x		x	x	x		x	x	x				
	8							x	x	x		x	x	x		x	x	x		x	x	x
	9 1/2	x	x									x	x	x		x	x	x		x	x	x
	11															x	x	x		x	x	x
	12 1/2	x	x																	x	x	x
NON-REINFORCED	2 1/2	x	x	x	x	x																
	3 1/2			x	x	x	x	x	x	x												
	5	x	x	x	x	x		x	x	x	x	x	x	x								
	6 1/2						x	x	x	x		x	x	x	x	x	x	x				
	8							x	x	x	x	x	x	x		x	x	x	x	x	x	x
	9 1/2	x	x									x	x	x	x	x	x	x		x	x	x
	11															x	x	x	x	x	x	x
	12 1/2	x	x																	x	x	x



Loop	Lane	Front Axle (Weight in kips)	Load Axle (Weight in kips)	Gross Weight (Weight in kips)
2	1	2	2	4
2	2	2	6	8
3	1	4	12	28
3	2	6	24	54
4	1	6	18	42
4	2	9	32	73
5	1	6	22.4	51
5	2	9	40	89
6	1	9	30	69
6	2	12	48	108

Figure 3. Axle load and vehicle type by lane.

FACTORS LEARNED OR DEVELOPED AT THE AASHO ROAD TEST

Major Technical Findings of the AASHO Road Test

AASHO Road Test Quantified the effect of pavement surface thickness carrying more load repetitions to failure.

- **Greater Pavement Thickness Better Performance**

Load Equivalency

The AASHO Road Test provided quantitative information about the relative damaging effect of heavy loads.

PSI – Performance Concept

Prior to the AASHO Road Test there was NO definition of pavement failure. Accumulated traffic to a fixed level of PSI (Roughness) was defined as Performance

(Basis of PMS)

Layer Equivalencies

Four types of base; gravel, cement stabilized, asphalt stabilized, and crushed stone were compared under load to define performance due to the quality of the base layer.

This is also a basis for Mechanistic Design

Value of Subbase to Reduce Pumping

PCC sections with gravel subbase performed much better than those laid directly on the clay. No chance to prove the value of stabilized subbases or variation in subbase quality.

However, subbases did pump under very heavy loads. This debunked the PCA claim that adding a gravel subbase prevents pumping permanently.

New Concepts in Pavement Engineering after the Road Test

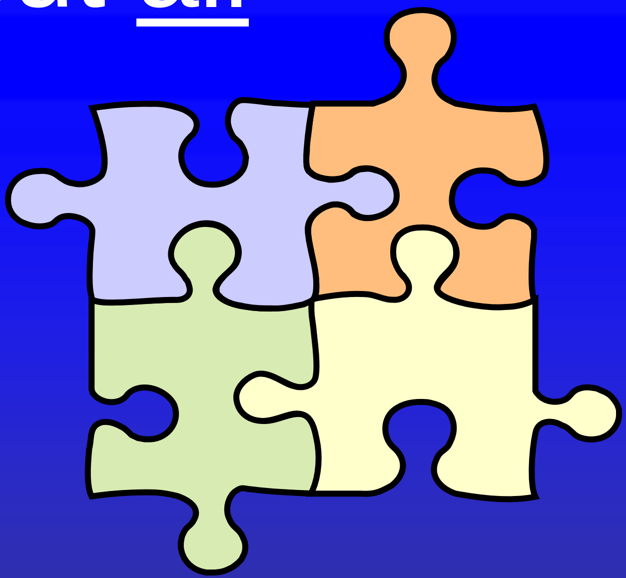
- **Modeling Pavement Performance**
- **Importance of Quality Data**
- **Collect Complete Data Sets**
- **Factorial Experiment Design and Testing**
- **Good Statistical Analysis of Data**

ROAD TEST

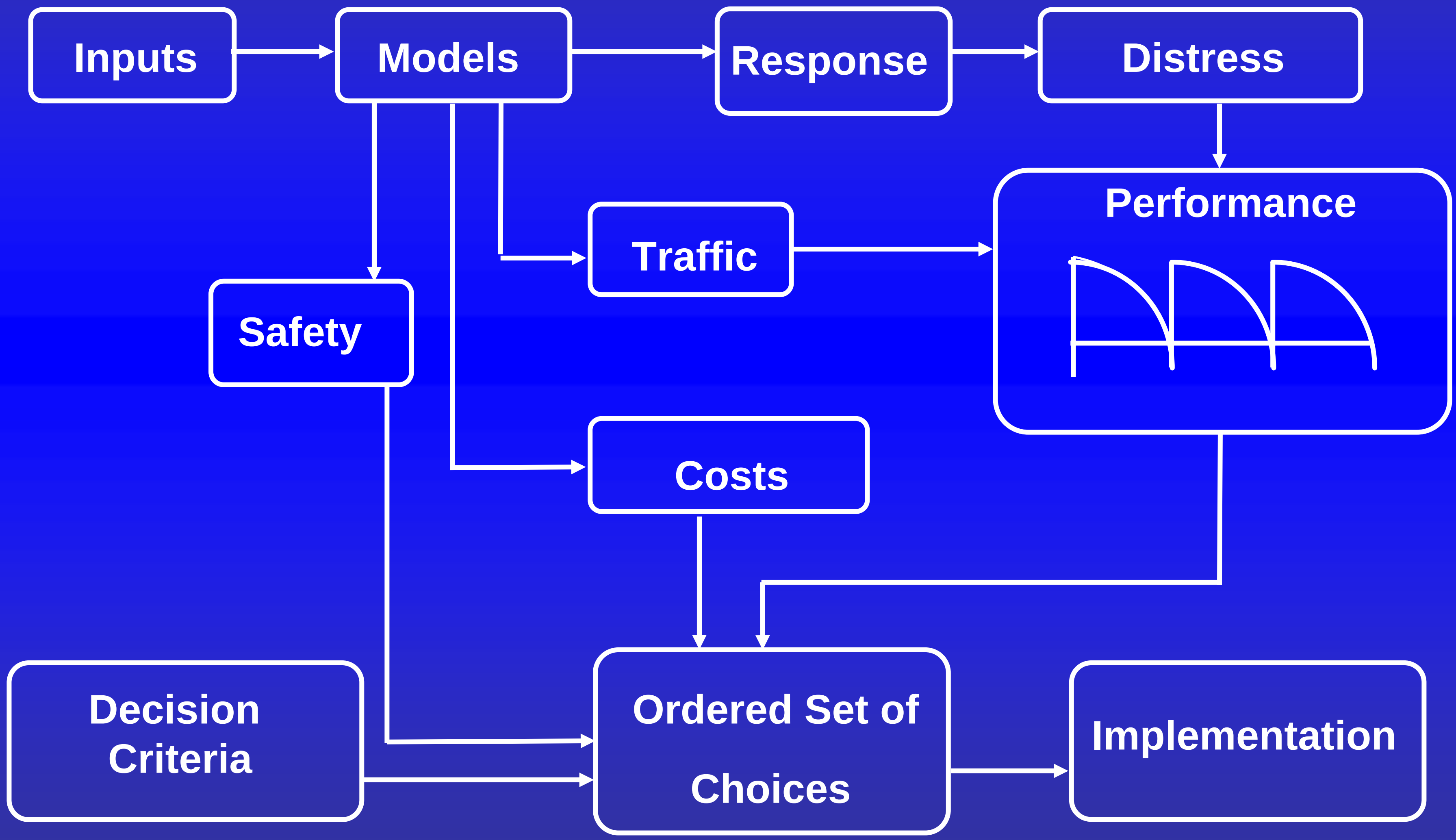
Led to very first AASHO Pavement Design Guide - 1962

Pavement Management

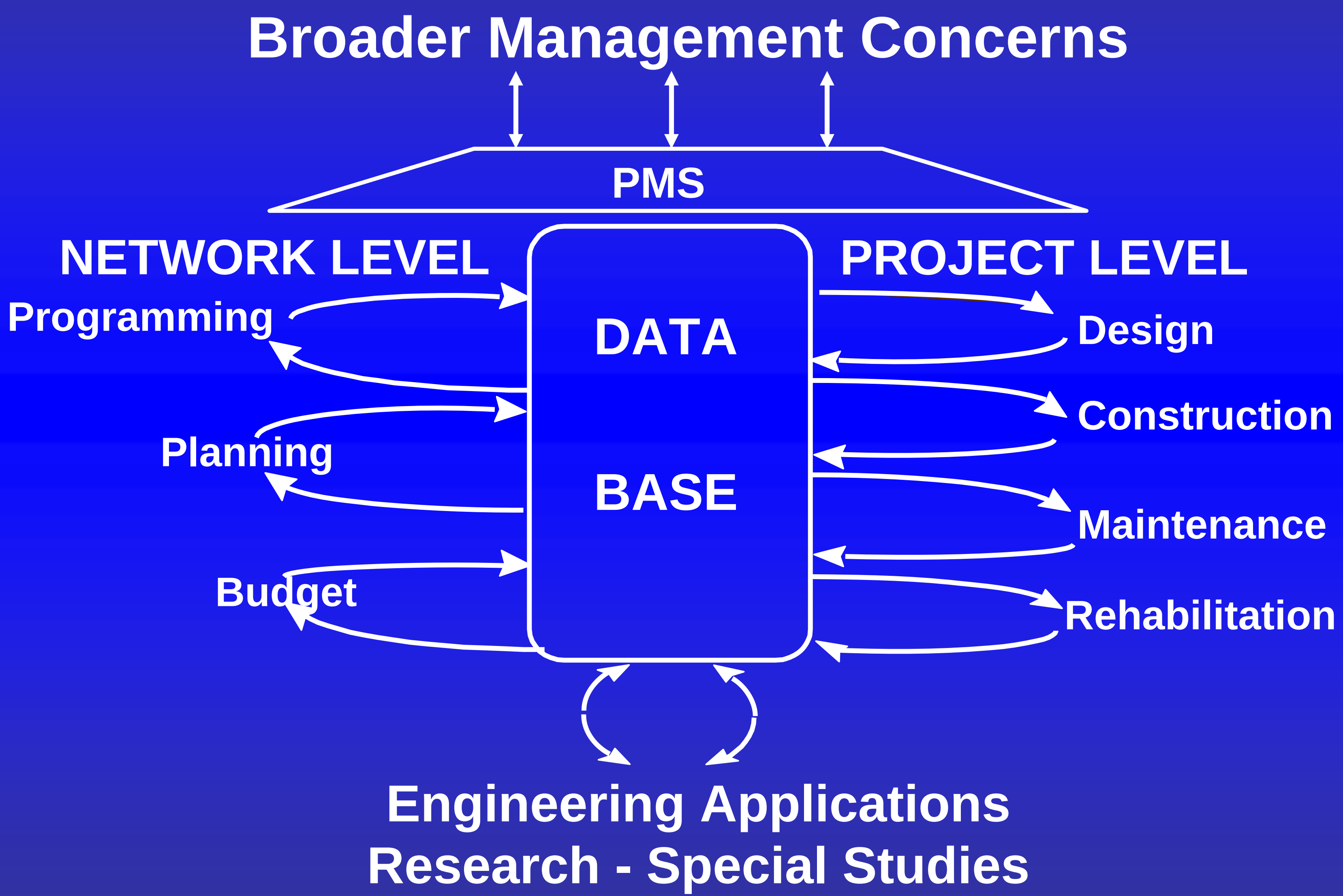
Is a coordinated systematic process for carrying out all activities related to providing pavements



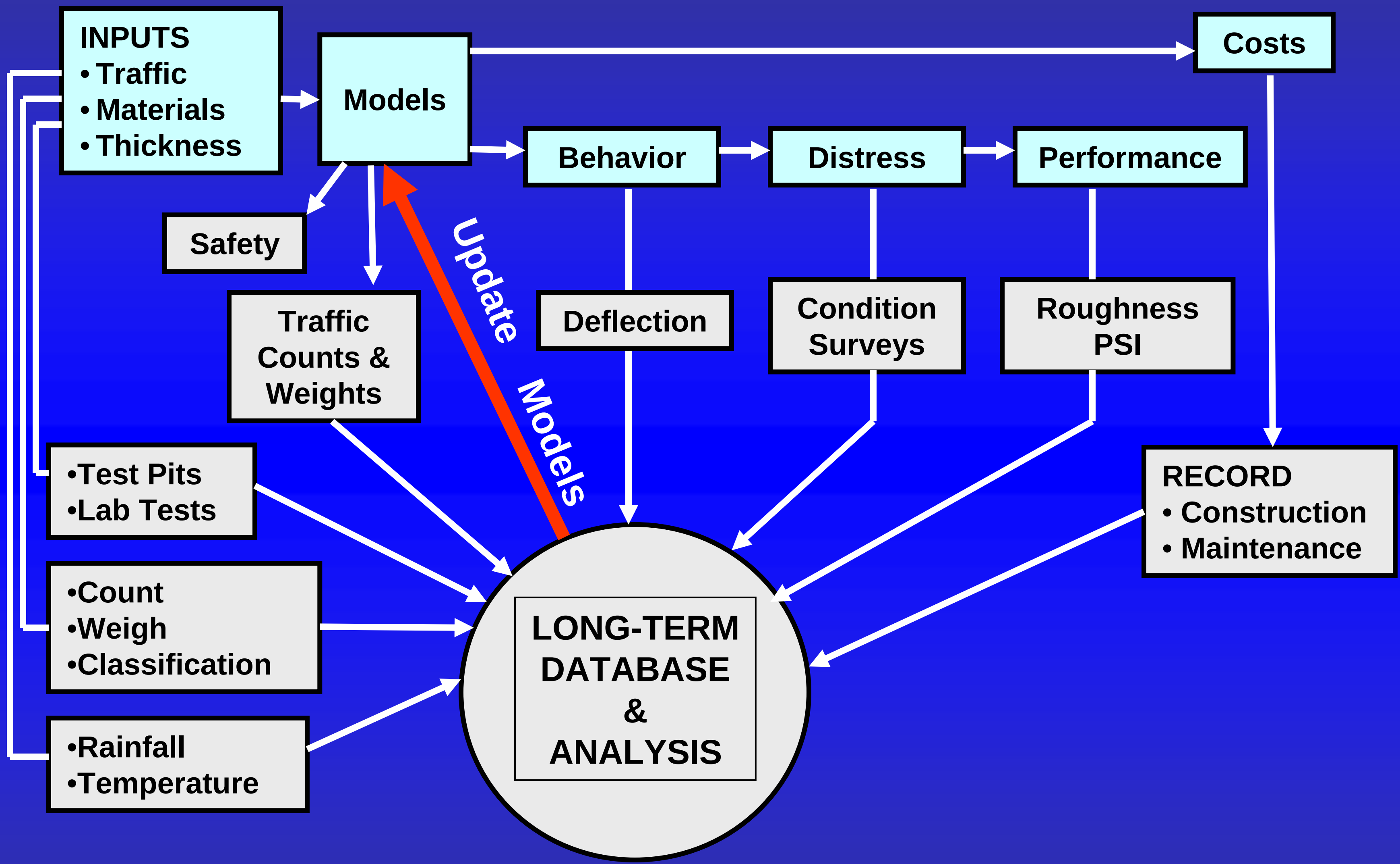
Major Components of a Project Level Pavement Design System



Components of PMS



Stay Tuned Please



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

EDUCATION

Pre 1970
Pavement Design Courses
General Civil Engr.

Develop PMS:
- **U of Tx Austin**
- **TX A&M**
- **MRD Corp**
- **U of Waterloo**

FHWA Intensive
6 Week Course
UT Austin

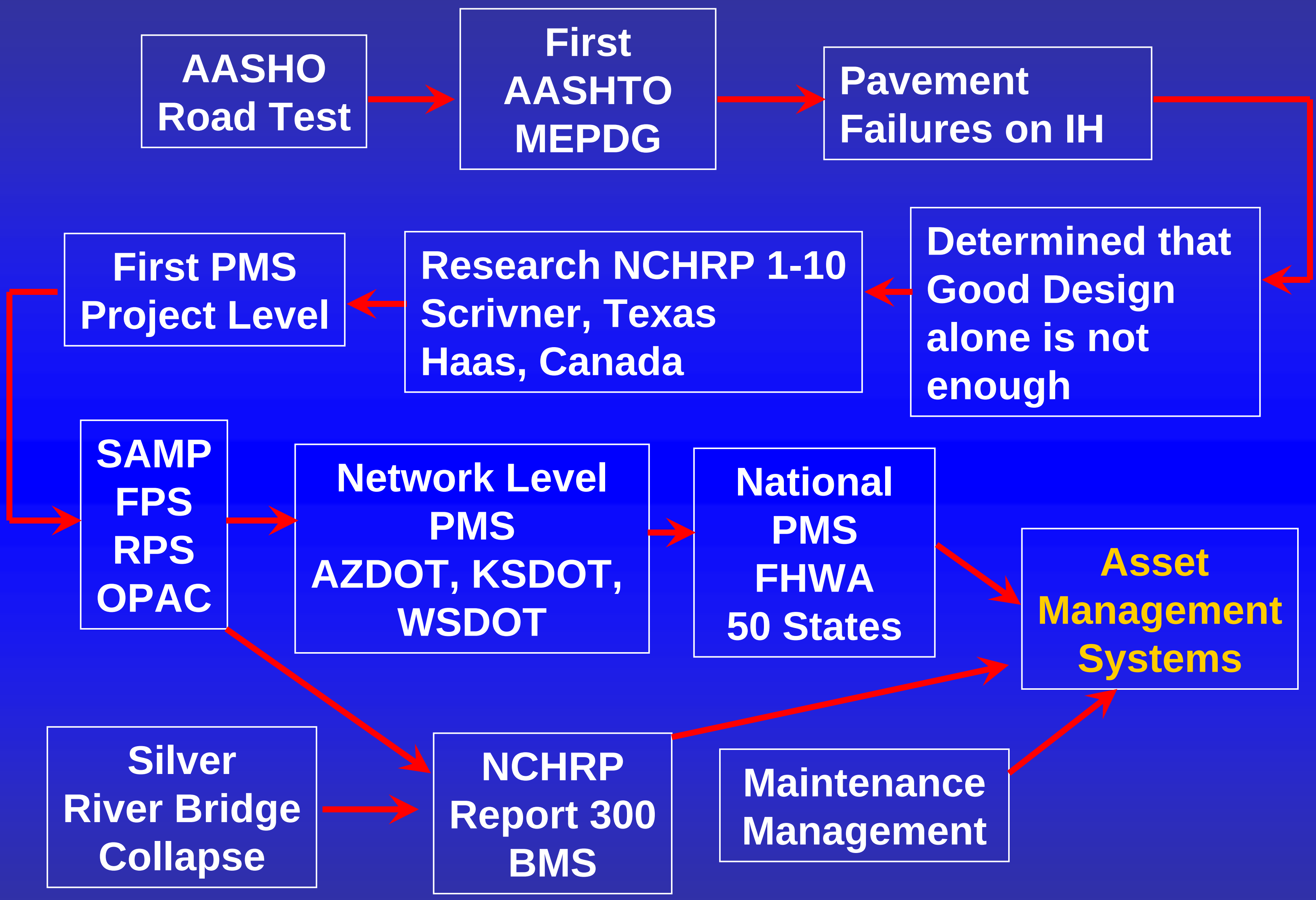
Short Courses and
Workshops 2 – 10 days

Haas & Hudson
Write Modern PMS
Text Books

More than 12 Universities develop PMS Courses

This Generation of Students Leads
the Spread of PMS Worldwide

Stay Tuned Please

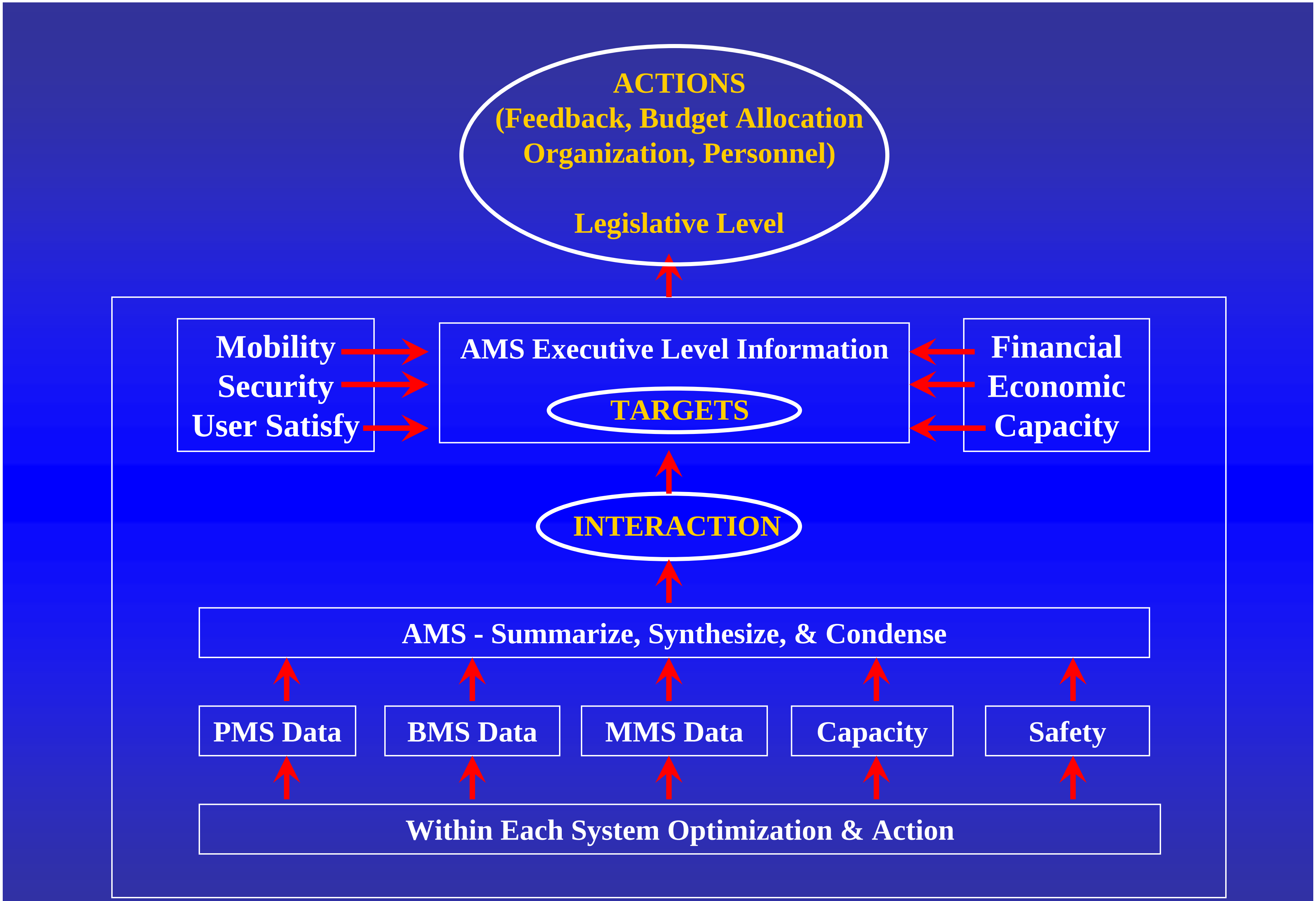

AASHO Road Test
First AASHTO MEPDG
Pavement Failures on IH
Determined that Good Design alone is not enough
Research NCHRP 1-10 Scrivner, Texas Haas, Canada
First PMS Project Level
SAMP FPS RPS OPAC
Network Level PMS AZDOT, KSDOT, WSDOT
National PMS FHWA 50 States
Asset Management Systems
Silver River Bridge Collapse
NCHRP Report 300 BMS
Maintenance Management

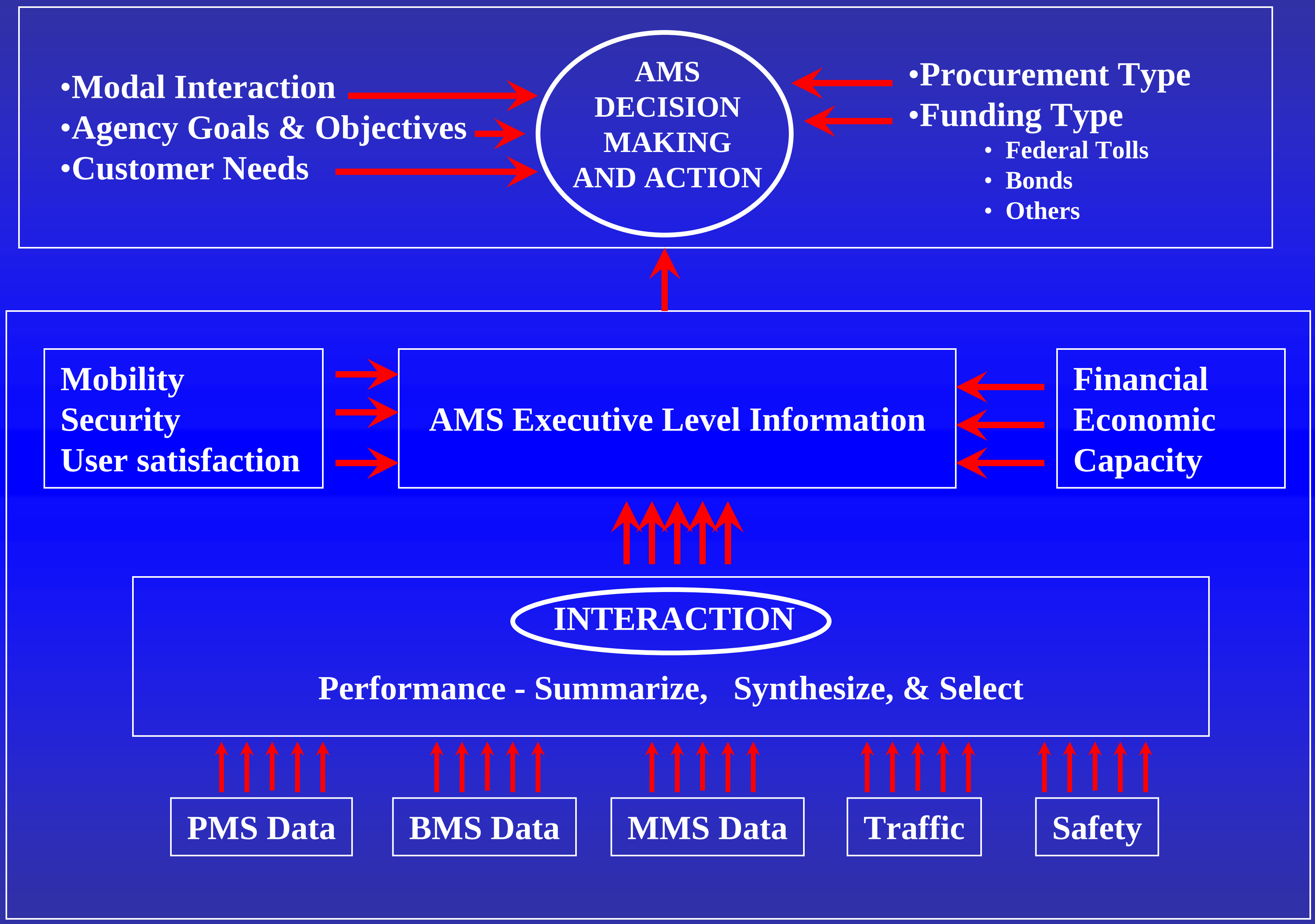
Pavement Research Funding

1987 – 2007 (approximate)

$190 Million – SHRP-LTPP	**90%**
$10 Million MEPDG	**5%**
$10 Million Data Collection, Traffic, etc.	**5%**

Stay Tuned Please


ACTIONS
(Feedback, Budget Allocation
Organization, Personnel)
Legislative Level
Mobility
Security
User Satisfy
AMS Executive Level Information
TARGETS
Financial
Economic
Capacity
INTERACTION
AMS - Summarize, Synthesize, & Condense
PMS Data
BMS Data
MMS Data
Capacity
Safety
Within Each System Optimization & Action



•Modal Interaction
•Agency Goals & Objectives
•Customer Needs
AMS DECISION MAKING AND ACTION
•Procurement Type
•Funding Type
• Federal Tolls
• Bonds
• Others
Mobility
Security
User satisfaction
AMS Executive Level Information
Financial
Economic
Capacity
INTERACTION
Performance - Summarize, Synthesize, & Select
PMS Data
BMS Data
MMS Data
Traffic
Safety

PUBLIC PRIVATE PARTNERSHIPS

Private Groups

- Toll Road Operators
- Concessionaires
- Contractors, etc.

Agree to provide acceptable level of service for reasonable – fair prices

↑

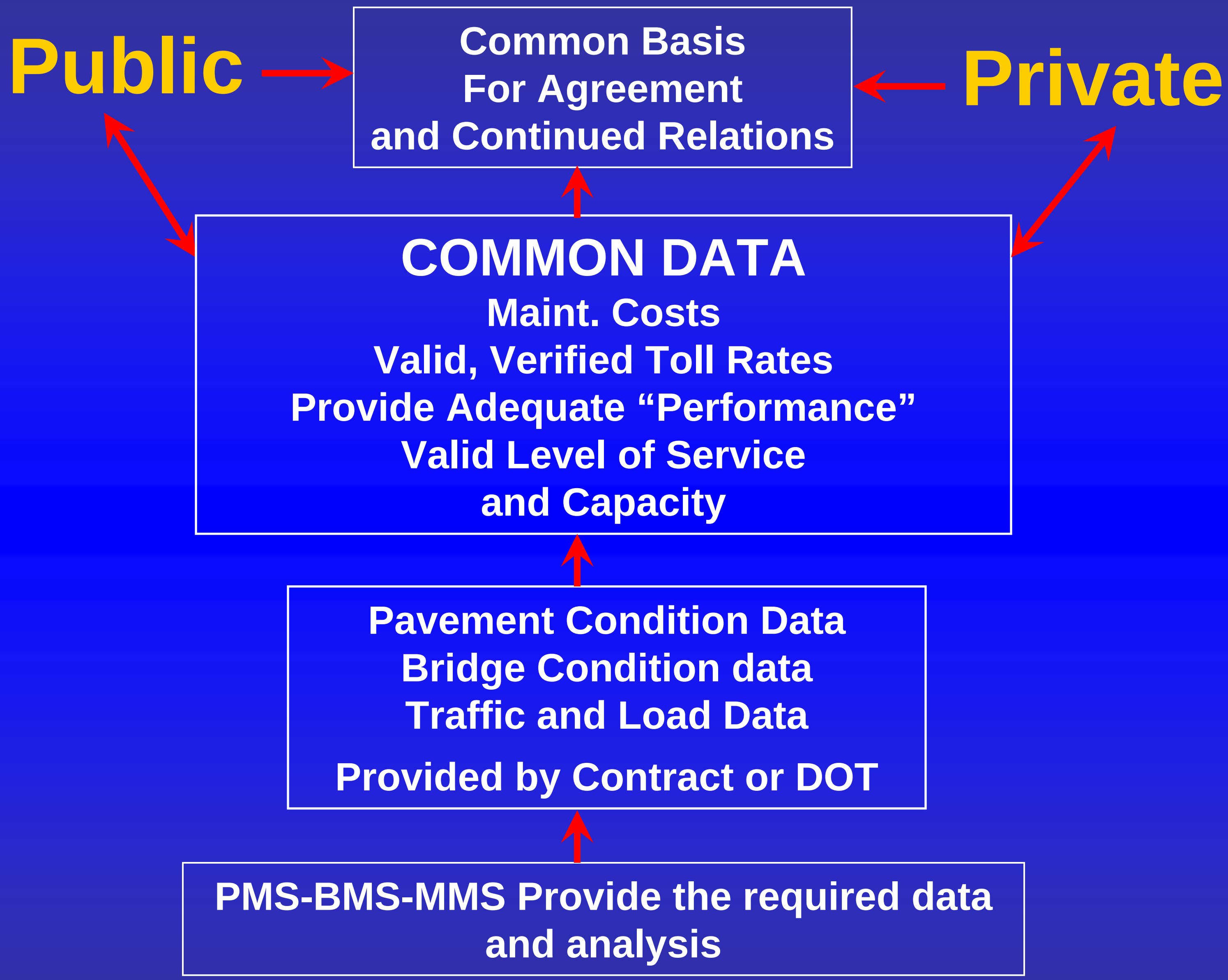
PUBLIC AGENCY Agrees to Contract

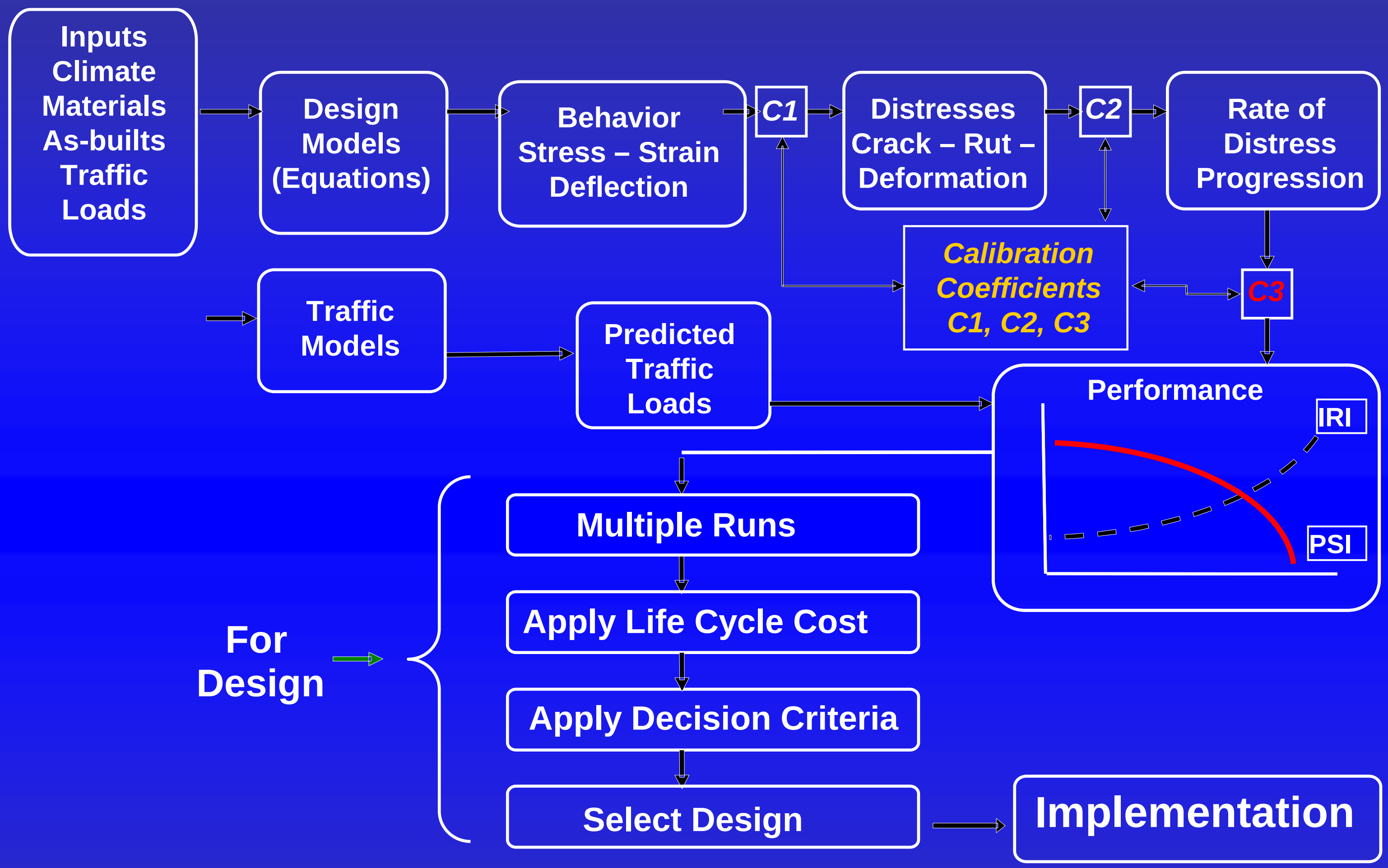
↑

Both parties agree to a valid – accurate set of performance measures and a fair way to determine them.

↑

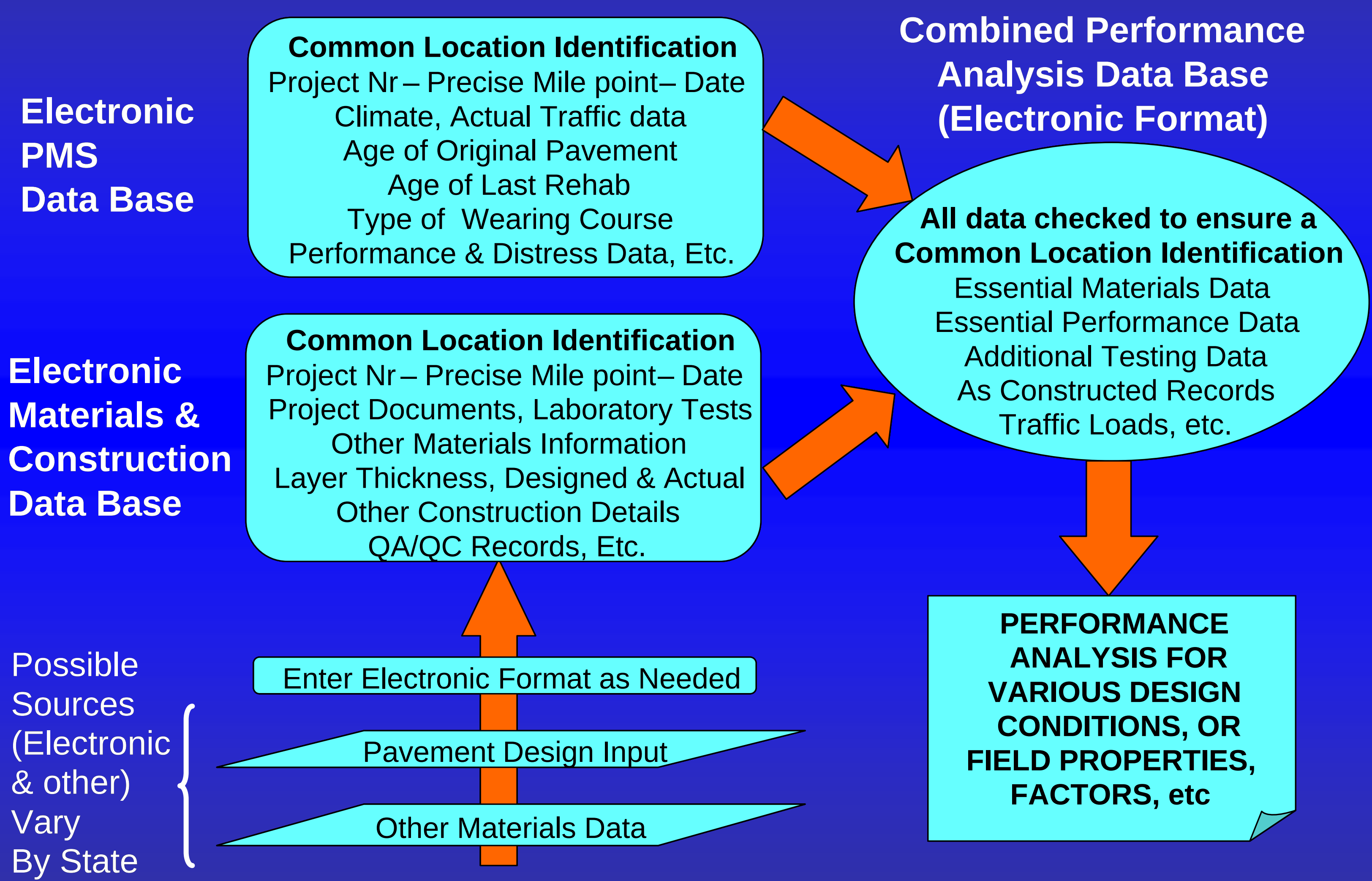
PMS, BMS, MMS provide the required data and analysis


Public
Common Basis
For Agreement
and Continued Relations
Private
COMMON DATA
Maint. Costs
Valid, Verified Toll Rates
Provide Adequate “Performance”
Valid Level of Service
and Capacity
Pavement Condition Data
Bridge Condition data
Traffic and Load Data
Provided by Contract or DOT
PMS-BMS-MMS Provide the required data
and analysis



Calibration of MEPDG

Note: Common link definition, valid location identification information and free electronic data exchange among data elements are essential



Don’t start vast projects with half vast ideas

Whatever you vividly Imagine, ardently Desire, sincerely Believe, and enthusiastically Act upon… must inevitably come to pass

- **Paul J. Meyer**