

# A History of Pavement Management

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Question: What do Pavement Management and Pornography have in common?

Answer: They are both difficult to define!

In 1964, Justice Potter Stewart tried to explain "hard-core" pornography, "I shall not today attempt further to define the kinds of material . . . but I know it when I see it . . . "

# What is a Pavement Management System?

- A PMS is a tool that can be used to make informed decisions about the maintenance and rehabilitation of a pavement network.
- APWA: A systematic method for routinely collecting, storing, and retrieving the kind of decision-making information needed to make use of limited maintenance (and construction dollars).



# What is a Pavement Management System? (cont.)

“...a coordinated set of activities, all directed toward achieving the best value possible for the available public funds in providing and operating smooth, safe, and economical pavements.”



# When did Pavement Management Begin?

The process evolved over time, but **1958** is as good a place to start as any.



# 1958 - 1968

## Which one of the following did NOT happen?:

- a) Elizabeth Taylor marries Eddie Fisher and Richard Burton
- b) Green Bay Packers win Super Bowl 1
- c) Richard Nixon wins Governor's election in California ✓
- d) New York Yankees play in World Series 6 times, and win 3 times.

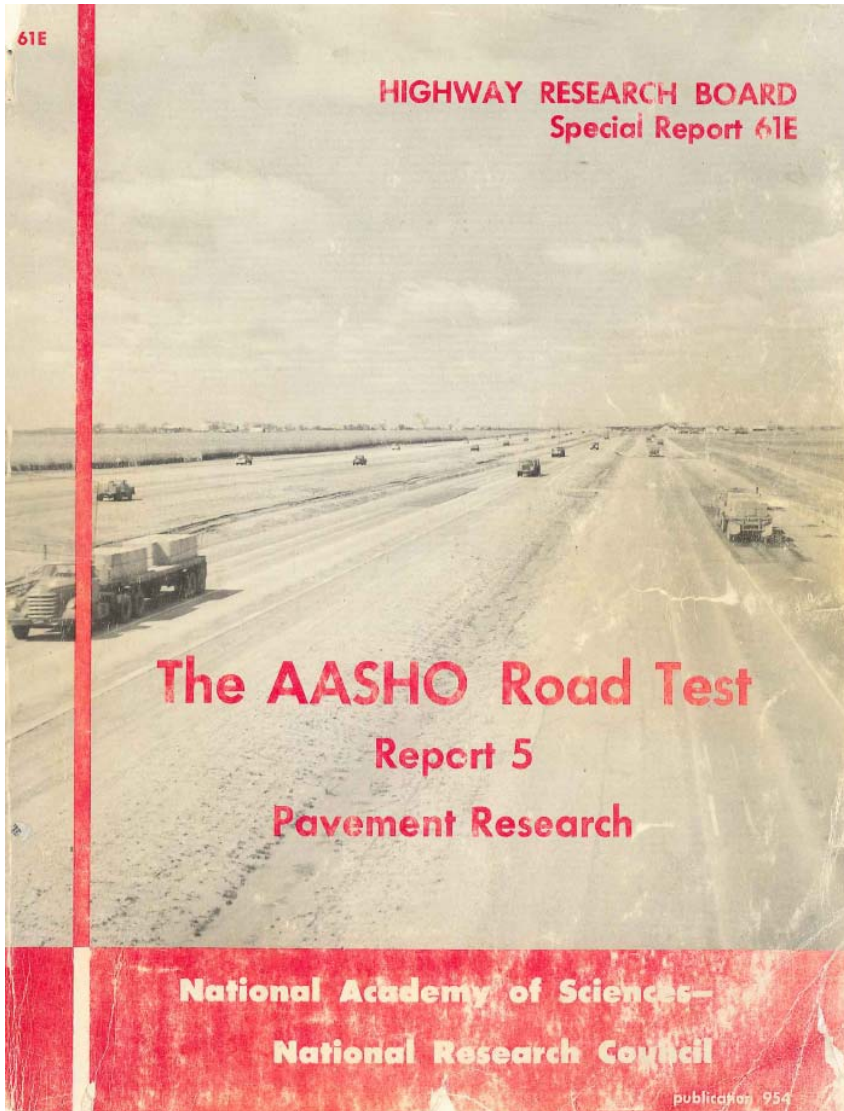


# 1958 - 1968

- Concept of Present Serviceability Index (PSI)
- AASHO Road Test (1958 – 1960)
  - Basis for most of pavement design today



# 1958: The concept of pavement performance is developed



How does the public perceive the quality of a road?

Acceptable ?

Yes

No

Undecided

5  
4 Very Good  
3 Good  
2 Fair  
1 Poor  
0 Very Poor

Section Identification \_\_\_\_\_ Rating \_\_\_\_\_

Rater \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_ Vehicle \_\_\_\_\_

The image shows a form for rating road serviceability. It includes a 5-point scale from 5 (Very Good) to 0 (Very Poor). There are three checkboxes for 'Acceptable?' (Yes, No, Undecided). Below the scale are fields for 'Section Identification', 'Rating', 'Rater', 'Date', 'Time', and 'Vehicle'.

Figure 1-F. Individual present serviceability rating form.

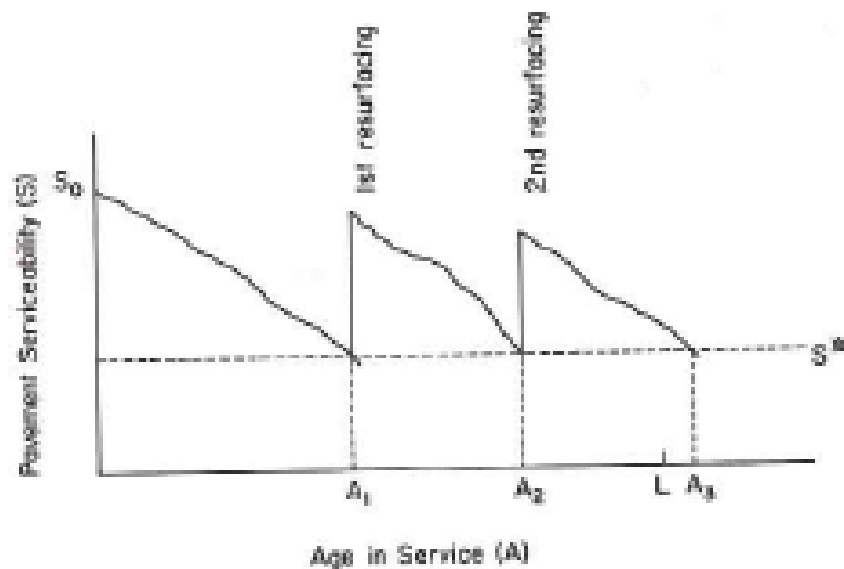
Highway Research Board 1962

# Present Serviceability Index (PSI)

Present Serviceability Rating (PSR) is a human rating, which can be estimated by a Present Serviceability Index (PSI), which can be measured.

PSI is measured through Slope Variance, Cracking & Patching, and Rutting (all measured at the AASHO Road Test).





- $S$  = pavement serviceability
- $S_0$  = pavement serviceability at time of construction
- $S^f$  = failure level of pavement serviceability
- $A_1$  = age at 1st resurfacing
- $A_2$  = age at 2nd resurfacing
- $A_3$  = age at failure of 2nd resurfacing
- $L$  = design life over which pavement strategies are compared

Figure 4. Generalized serviceability profile of highway pavements.

Hutchinson & Haas, 1968



# 1968 - 1978

Which ONE of the following DID happen?:

- a) Elizabeth Taylor marries Richard Burton and John Warner ✓
- b) Pittsburgh Steelers go to Super Bowl twice and win once
- c) Richard Nixon is impeached and removed from office as President
- d) *Deliverance* beats out *The Godfather* for Best Picture in 1972

# 1968 - 1978

- Concept of “systems” applied to pavements
- First publications on Pavement Management
- Washington State begins work on PMS
- Three individuals stand out:
  - Ralph Haas (Univ. of Waterloo, Ontario)
  - W. Ronald Hudson (Univ. of Texas)
  - Fred Finn (Consulting Engineer)



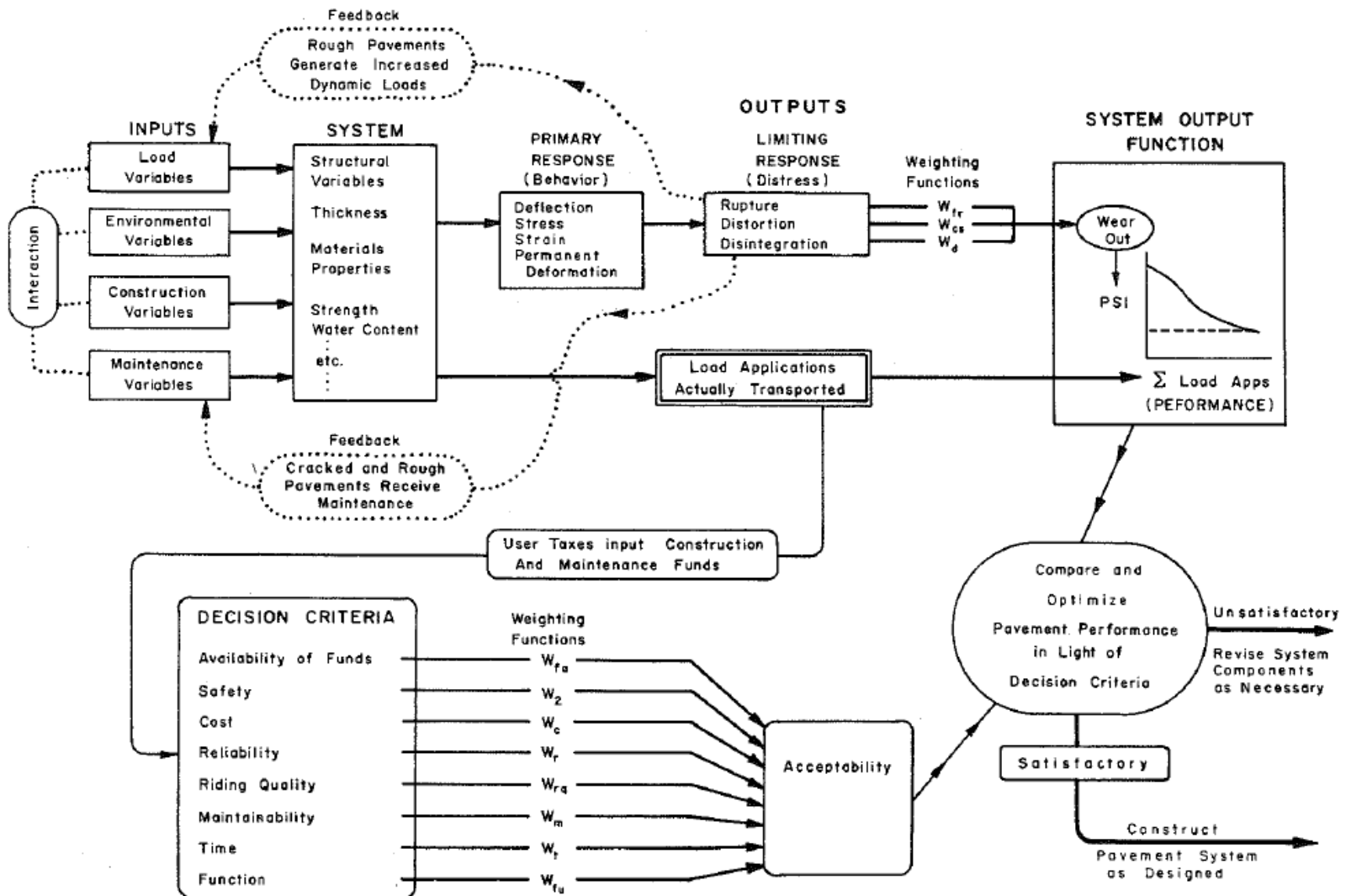


Figure A-4. Block diagram of the pavement system.

Hudson & McCullough, 1973

# Project Level PMS

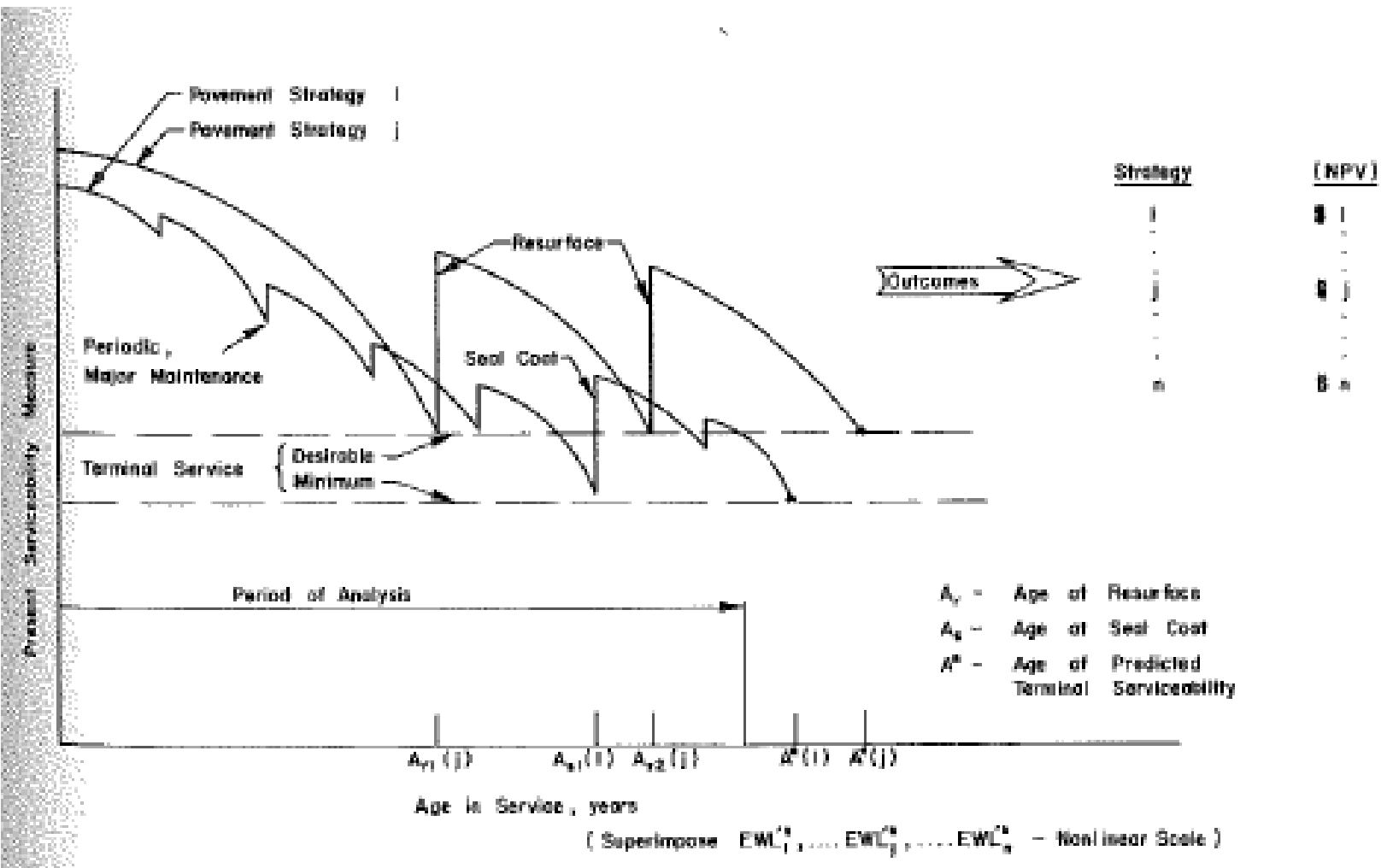
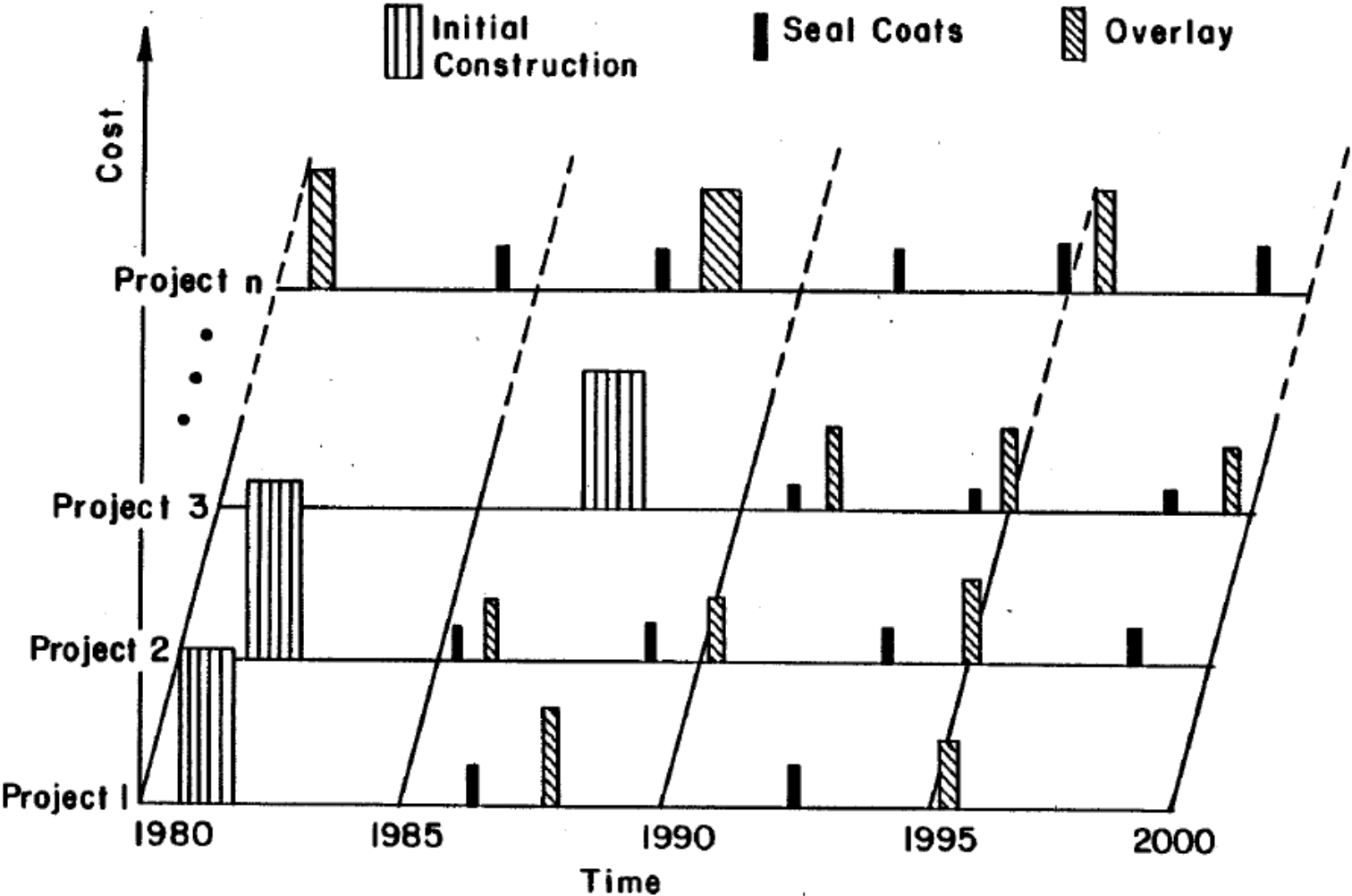


Figure 1. Gross output of a pavement system in terms of performance and value implications.

Haas & Hudson, 1971

# Network Level PMS



Hudson & McCullough, 1972

# **PAVEMENT MANAGEMENT SYSTEM**

## **FEASIBILITY STUDY**

F. FINN, R. KULKARNI AND K. NAIR  
MATERIALS RESEARCH & DEVELOPMENT  
A DIVISION OF WOODWARD-LUNDGREN & ASSOCIATES  
2730 ADELINE STREET  
OAKLAND, CALIFORNIA 94607

**AUGUST 1974**  
**FINAL REPORT**

PREPARED FOR:  
WASHINGTON HIGHWAY COMMISSION  
DEPARTMENT OF HIGHWAYS  
OLYMPIA, WASHINGTON 98504



Washington State DOT

# 1978 - 1988

Which ONE of the following did NOT happen?:

- a) The Los Angeles Dodgers go to the World Series twice and win both times
- b) The Berlin Wall falls ✓
- c) Rain Man wins the Oscar for Best Picture in 1988
- d) Ronald Reagan wins two terms as US President

# 1978 - 1988

- Pavement Management “takes off”
- FHWA issues first policy on Pavement Management
- IRI developed
- Many states and local governments develop experience with PMS
- First International Conference on PMS



# 1978 – 1988 (cont.)

- Pavement condition survey vehicles developed
  - Inertial profilometer
  - Automated Road Analyzer (ARAN)
  - Infrastructure Management Systems (IMS)
  - Dynaflect, Road Rater, FWD
- ISTEA



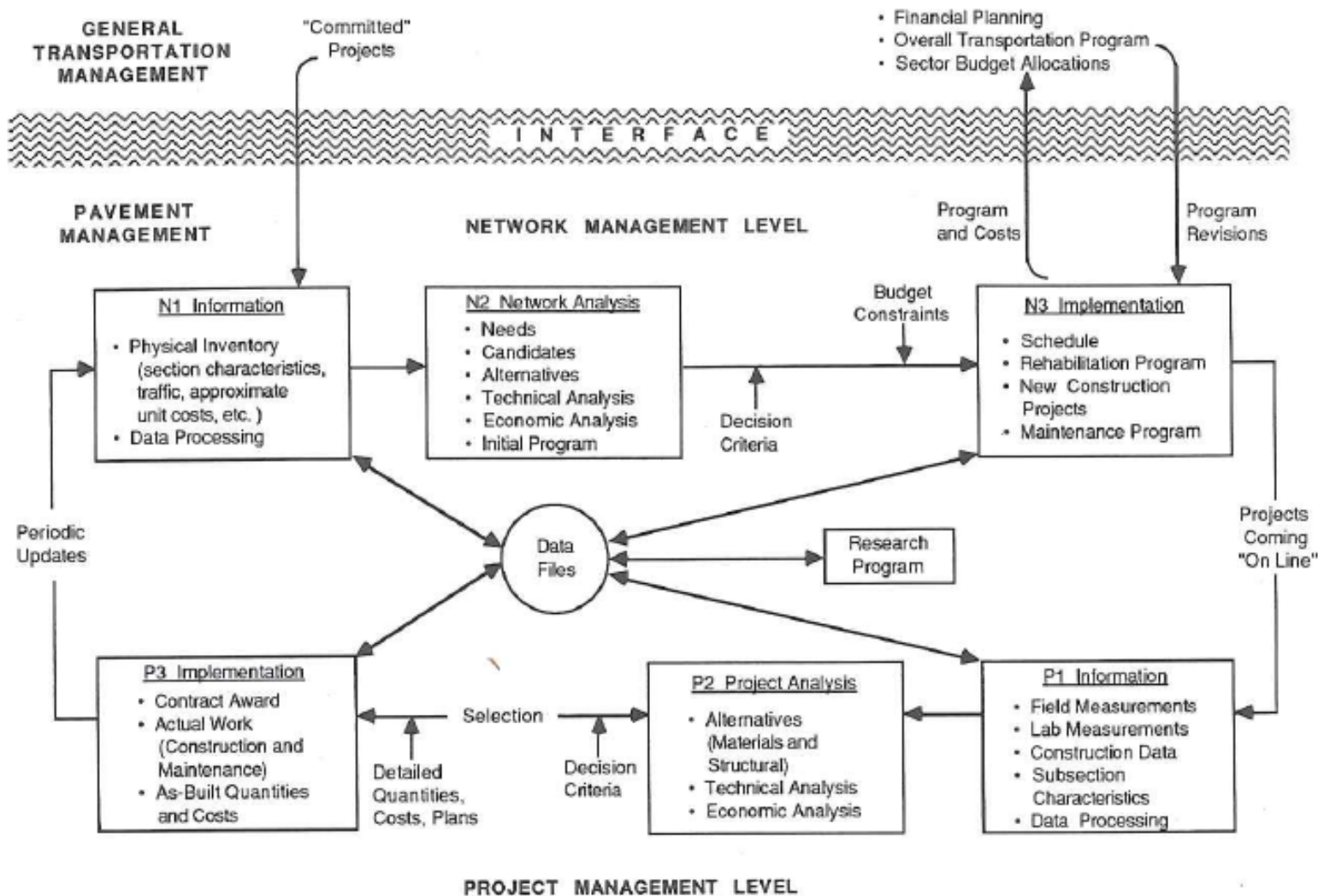


Figure 4.4 Information flows in a pavement management system. [Hudson 79].

Hudson, 1979

PTI 8503

PAVEMENT MANAGEMENT SYSTEMS  
A REVIEW OF CURRENT PRACTICE

Part II

MEETINGS WITH STATE AND LOCAL TRANSPORTATION OFFICIALS

Interim Report

Prepared for

IBM

by

David R. Luhr

The Pennsylvania Transportation Institute  
The Pennsylvania State University  
University Park, PA 16802

January 1985



Washington State DOT

# Some Existing Pavement Management Systems in 1985

- State Departments of Transportation
  - Idaho
  - South Dakota
  - Washington
  - Pennsylvania
  - Colorado
  - Texas
  - Georgia
  - Missouri
  - Ontario
  - New York
  - California



\*\*\*\*\*  
 \* SUMMARY DISTRIBUTIONS \*  
 \* OF ROAD MILES BY \*  
 \* EVALUATION INDICES FOR \*  
 \* DISTRICT NO. 1 \*  
 \*\*\*\*\*

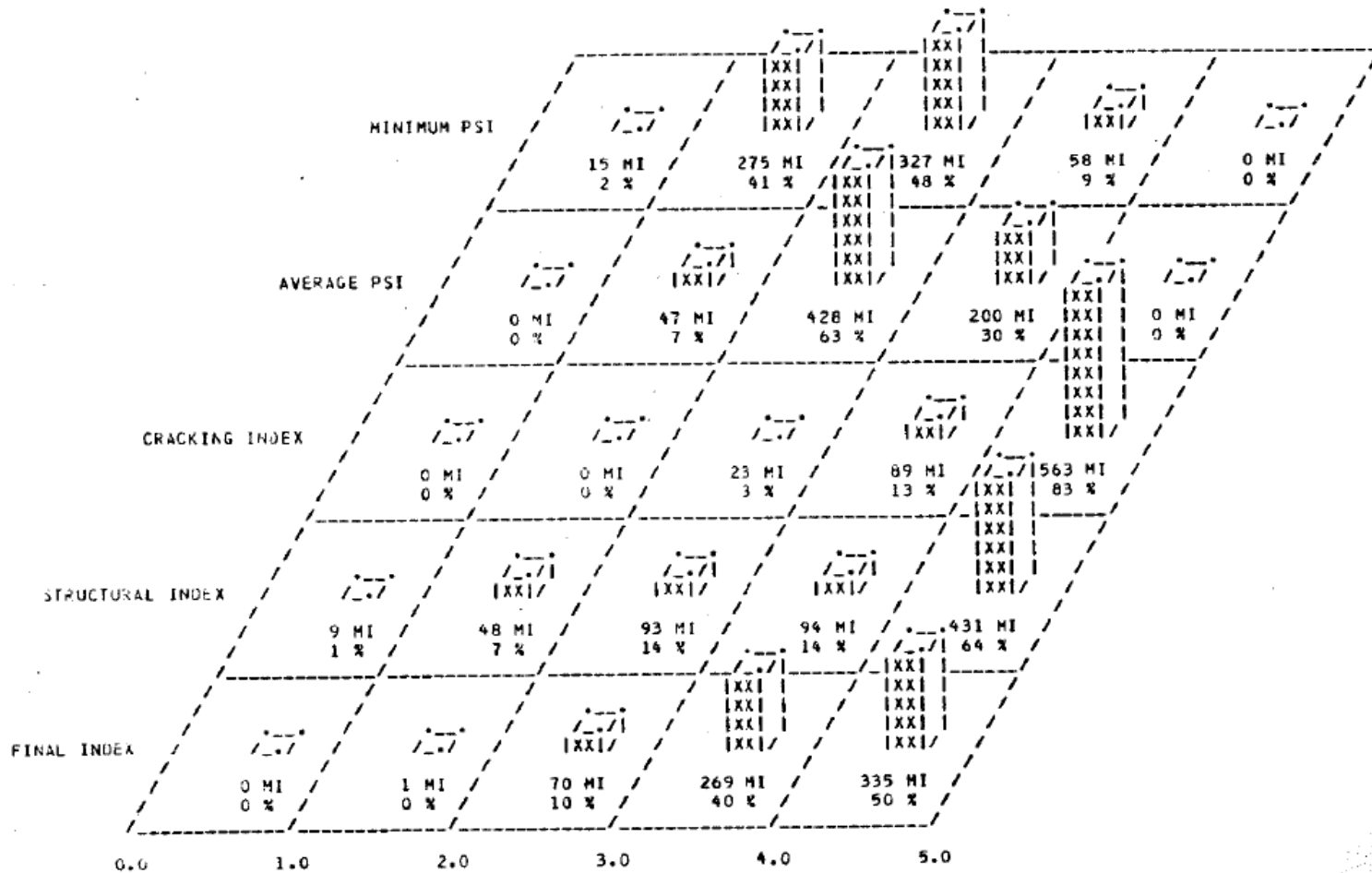


Figure 3. Idaho Transportation Department graphical presentation of condition survey indices.



D	SP	HEG	END	HEG	END	PROJ	ENC	HWY	NUM	RDW	RSW	LSH	LAST	COMPLT	CNT	SURFACE	BASE			
0	0000	0000	0000	0000	0000	LENG	CLS	TYP	LNS	WIDTHS	CONTR	M-YR	TYP	TYP	THK	TYPE				
3	3	2066	2228	2331	2335	2497	162	R-1	R	0	2	23	3	3	09497	--73	3	6	15	10

PERFORMANCE HISTORY					APPROXIMATE TRAFFIC DATA				PERFORMANCE EQUATION			
YEAR	73	75	77	79	79 ADT	3800	EQUA CONST =	99.77	79 ADT	3800	EQUA CONST =	99.77
AGE	0	2	4	6	GROWTH RATE	6.8%	EQUA COEFF =	-0.15711	GROWTH RATE	6.8%	EQUA COEFF =	-0.15711
RIDE RATING	0.99	0.99	0.97	0.98	SINGLE UNITS	5%	EQUA POWER =	2.50	SINGLE UNITS	5%	EQUA POWER =	2.50
STRUCR RATING	100.0	100.0	97.3	88.0	COMBINATIONS	2%	R SQUARE =	0.99846	COMBINATIONS	2%	R SQUARE =	0.99846
COMBD RATING	100.0	98.6	94.8	85.9	TRAFFIC INDEX	6.3	STD ERROR =	0.30	TRAFFIC INDEX	6.3	STD ERROR =	0.30
HIGH RATING	100.0	99.2	98.7	98.4	K = 17%	0 = 58%	TIME TO 60 =	9.15	K = 17%	0 = 58%	TIME TO 60 =	9.15
LOW RATING	100.0	98.1	91.4	77.5	2 AXLE TRUCKS =	3.3%	TIME TO 50 =	10.01	2 AXLE TRUCKS =	3.3%	TIME TO 50 =	10.01
HIGH FRICTION	0	62	51	48	3 AXLE TRUCKS =	2.0%	TIME TO 40 =	10.77	3 AXLE TRUCKS =	2.0%	TIME TO 40 =	10.77
LOW FRICTION	0	60	49	46	4 AXLE TRUCKS =	0.3%	TIME TO 30 =	11.45	4 AXLE TRUCKS =	0.3%	TIME TO 30 =	11.45
AVG FRICTION	0	60	50	46	5 AXLE TRUCKS =	1.3%	TIME TO 20 =	12.09	5 AXLE TRUCKS =	1.3%	TIME TO 20 =	12.09

AGE

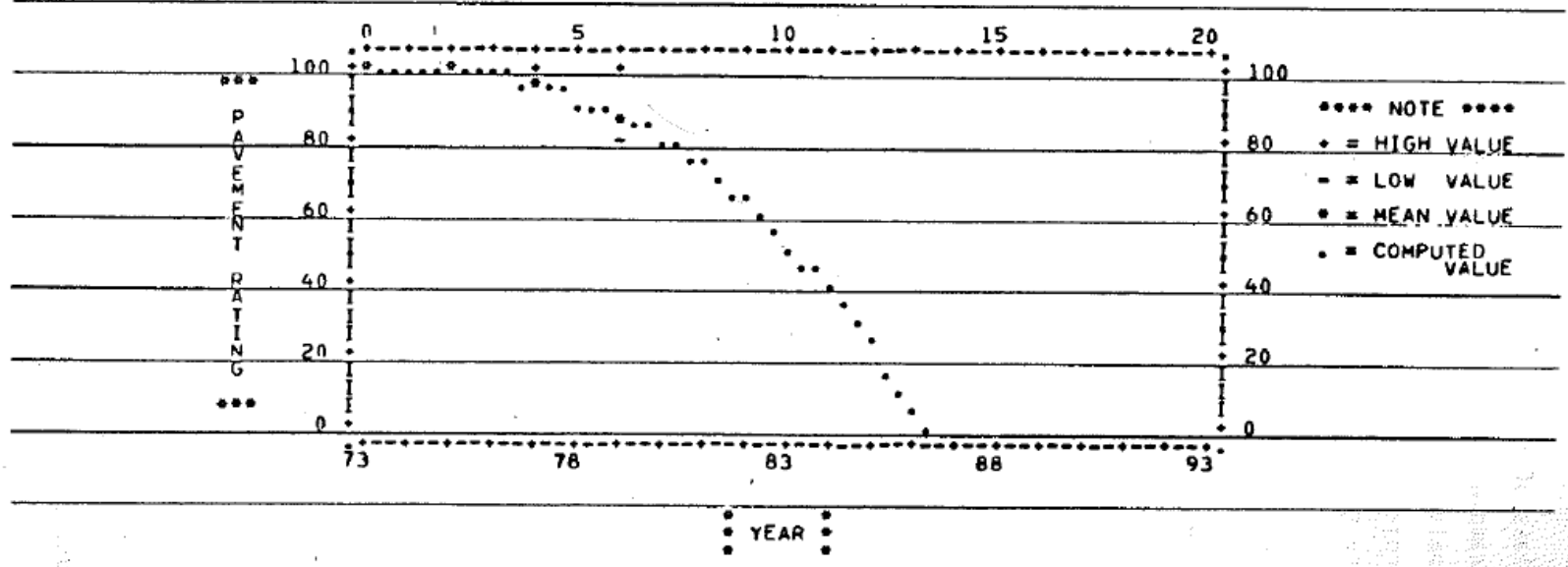


Figure 12. Washington State Department of Transportation project performance data.

# Some Existing Pavement Management Systems in 1985 (cont.)

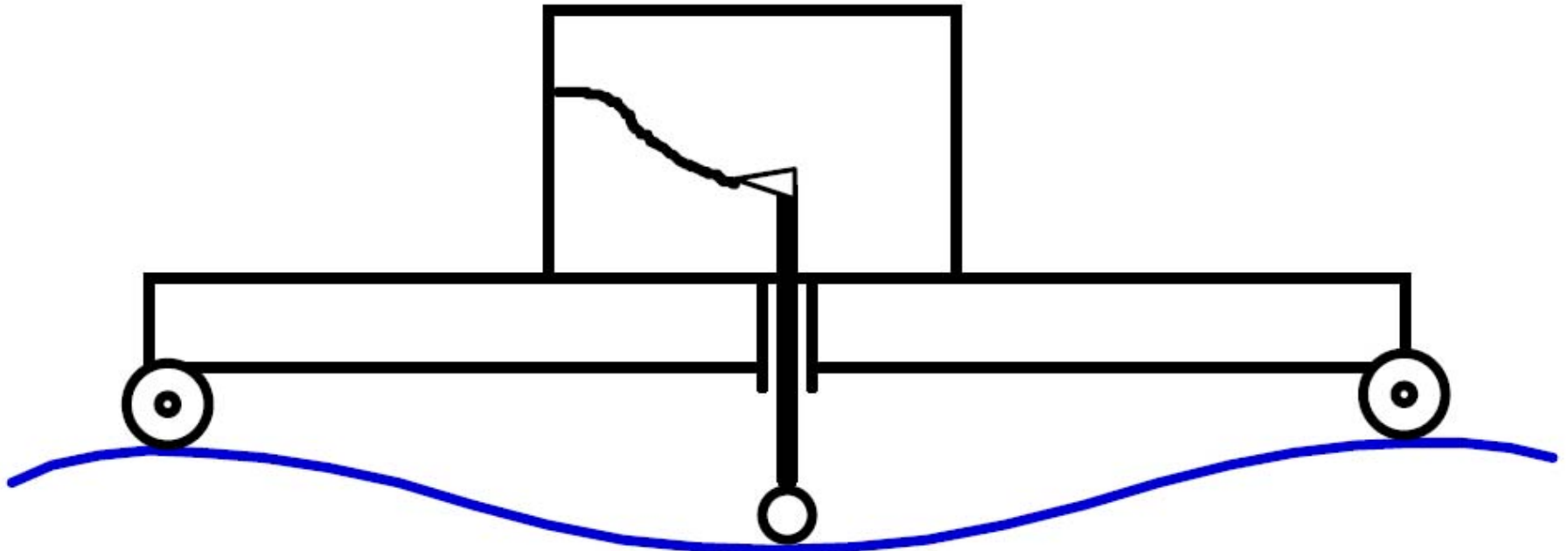
- Local Governments
  - Metropolitan Transportation Commission
  - King County Dept. of Public Works
  - City of Atlanta, GA
  - Metro Toronto Dept. of Roads and Traffic



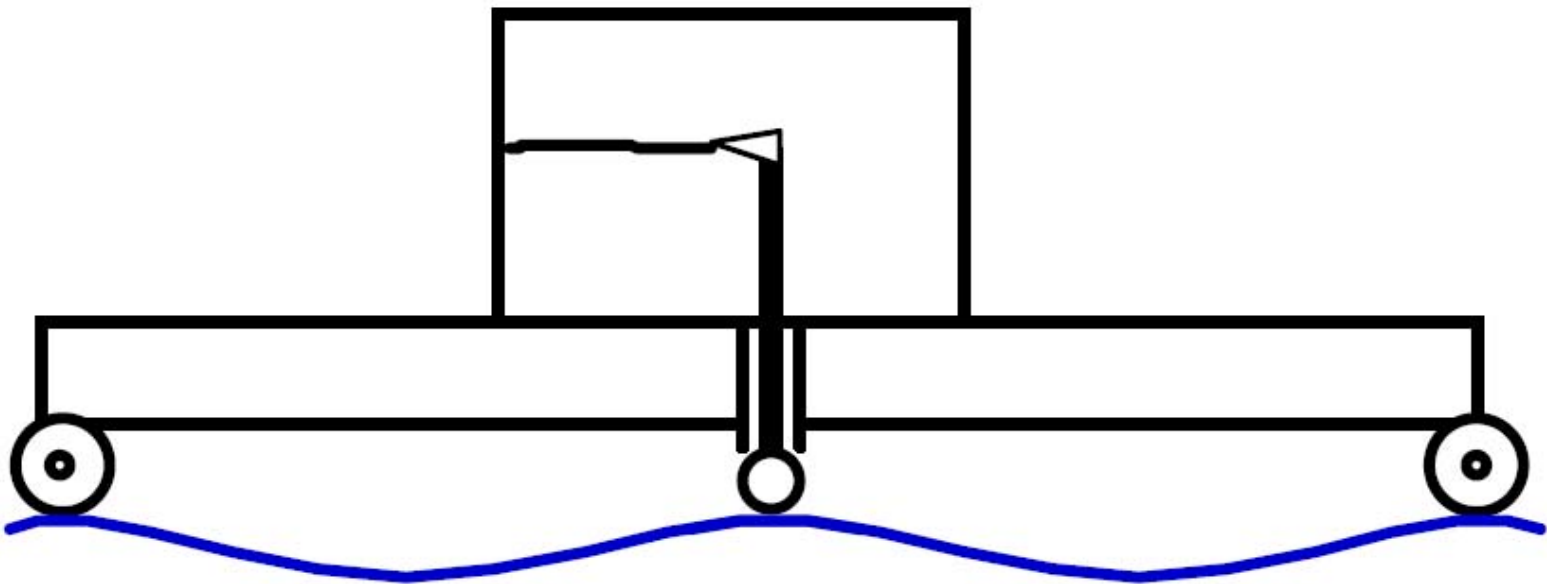
# Profilograph



# Rolling Straightedge Response

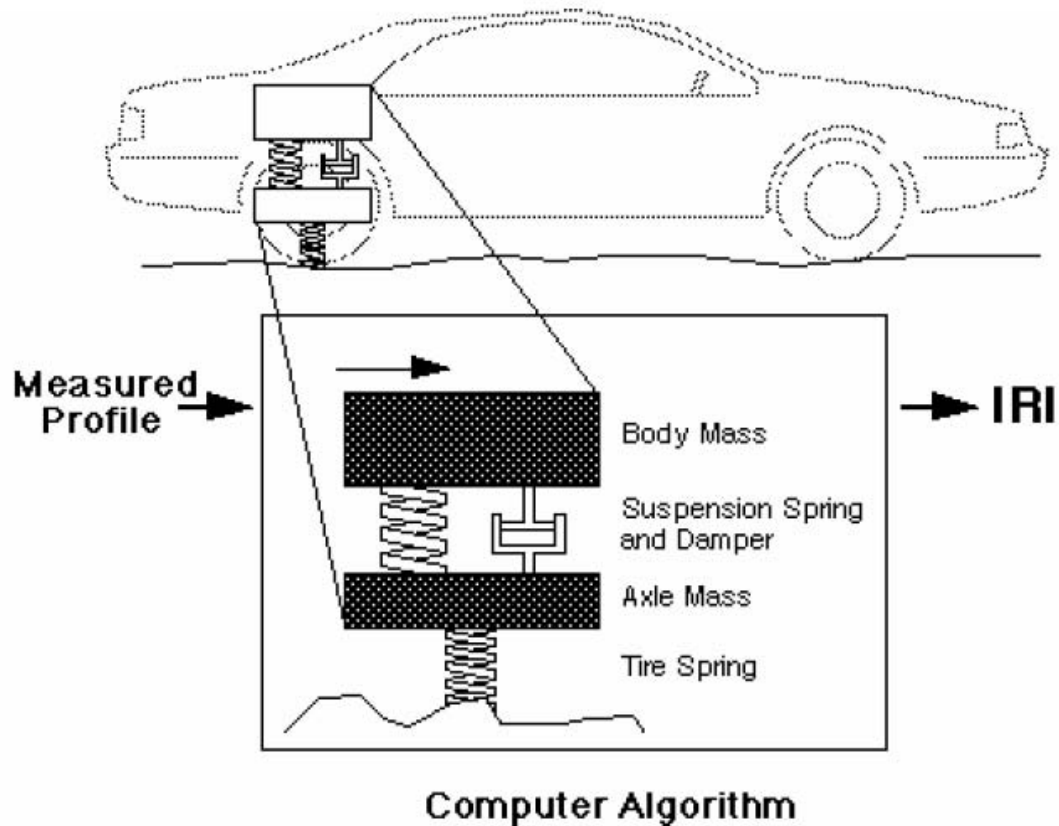


# Rolling Straightedge Response



# International Roughness Index

(Response-type Index)



# Different Variants of IRI

- IRI (in/mi) in one wheelpath
- Mean Roughness Index (MRI) (in/mi)
  - Average of the IRI from each wheelpath
- Half-Car Index (HRI) (in/mi)
  - Average profile from left wheelpath and right wheelpath
  - Run IRI software with average profile



# 1988 - 1998

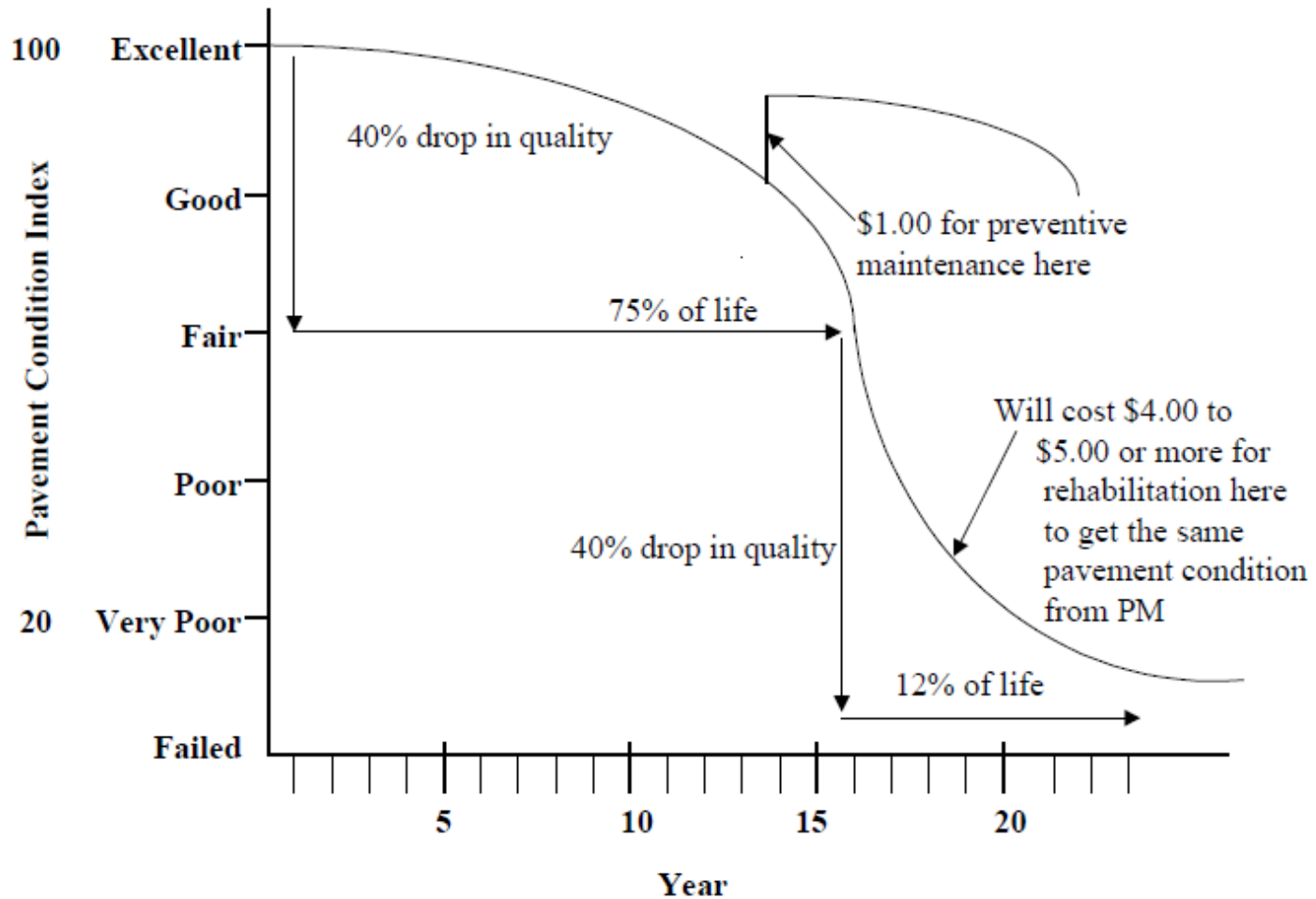
Which ONE of the following DID happen?:

- a) The Cincinnati Bengals go to the Super Bowl twice and win twice
- b) Pulp Fiction beats Forest Gump as Best Picture in 1994
- c) A man shoots President Ronald Reagan to get Jodie Foster's attention ✓
- d) Bill Clinton is impeached and removed as President of the United States

# 1988 - 1998

- GIS is developed for Pavement Management applications
- “Expert Systems” are developed
- Personal Computers “take off”
- Strategic Highway Research Program (SHRP)
- First trials with “automated” image recognition of pavement distress
- Development of Ground Penetrating Radar





O'brien, 1989



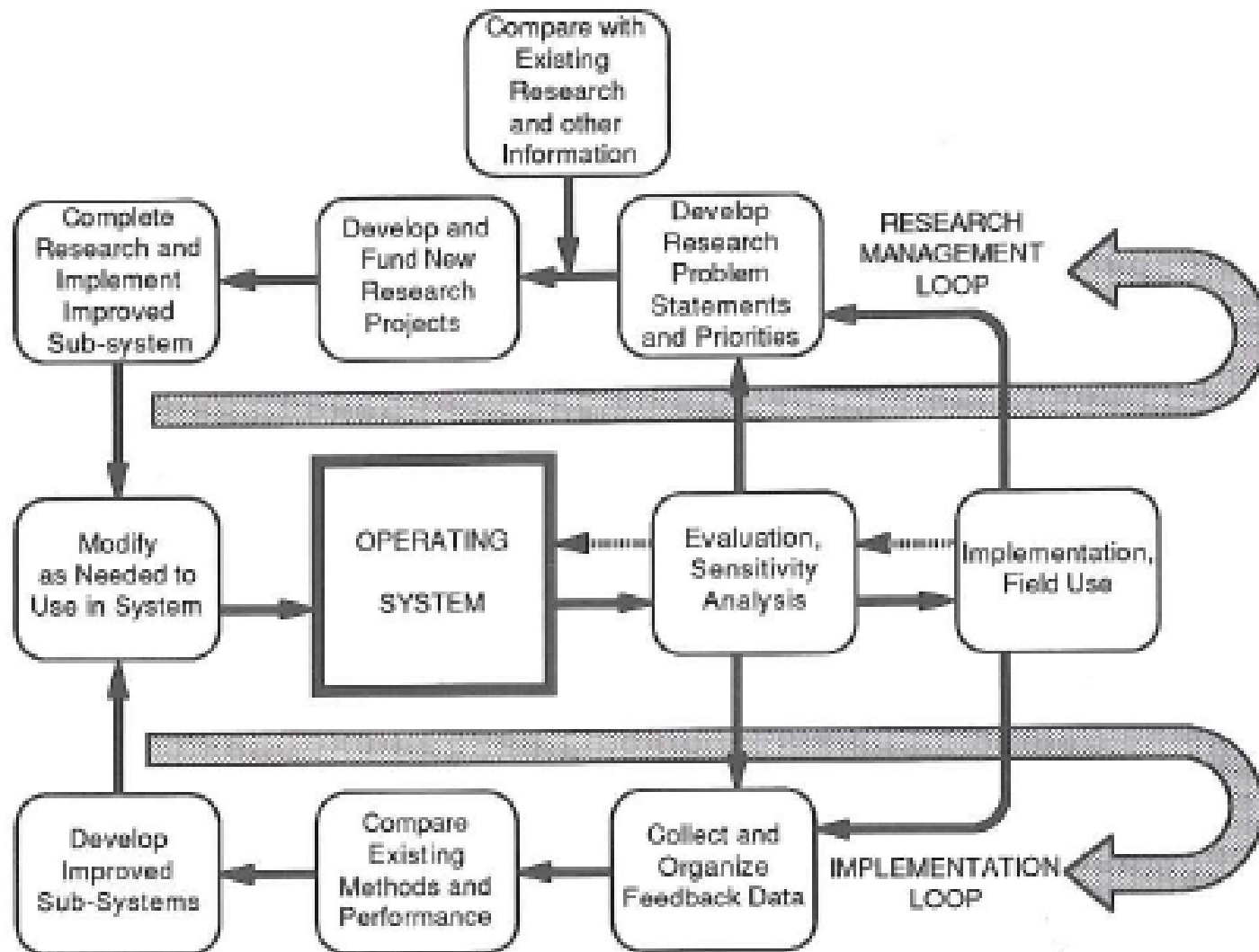
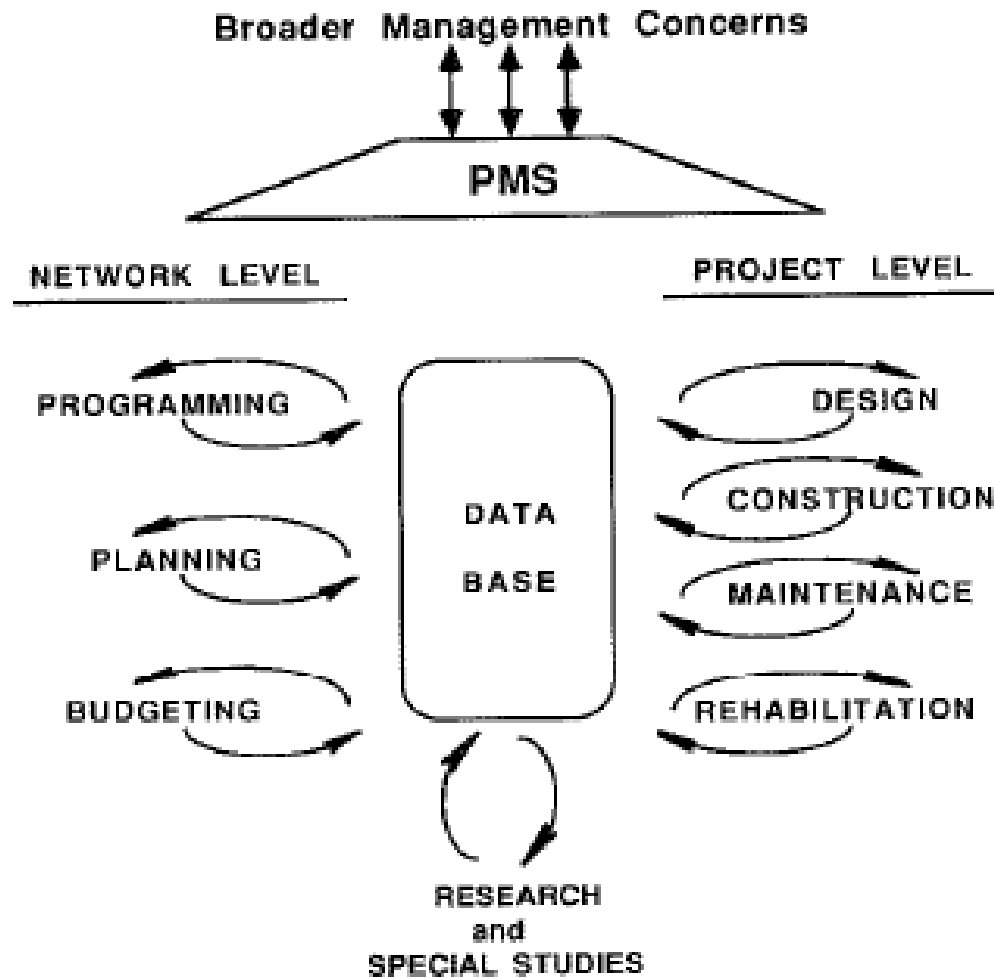


Figure 5.1 Cyclic improvements of pavement design and management system.

Haas, et al, 1994



Major components of a pavement management system.

Haas, et al, 1994

# 1998 - 2008

Which ONE of the following did NOT happen?:

- a) Univ. of Florida wins back-to-back College Basketball Championships
- b) The *Lord of the Rings* wins Best Picture in 2003
- c) Al Gore receives more votes for President than George W. Bush
- d) The New York Mets beat the New York Yankees in the 2000 World Series ✓

# 1998 - 2008

- Asset Management “takes off”
- “Pavement Preservation” new buzz word
- Internet “takes off”
- Advances in IT, allowing for more data storage and data sharing
- GPS moves from military to commercial applications
- Advances in digital instrumentation
  - Smaller, faster



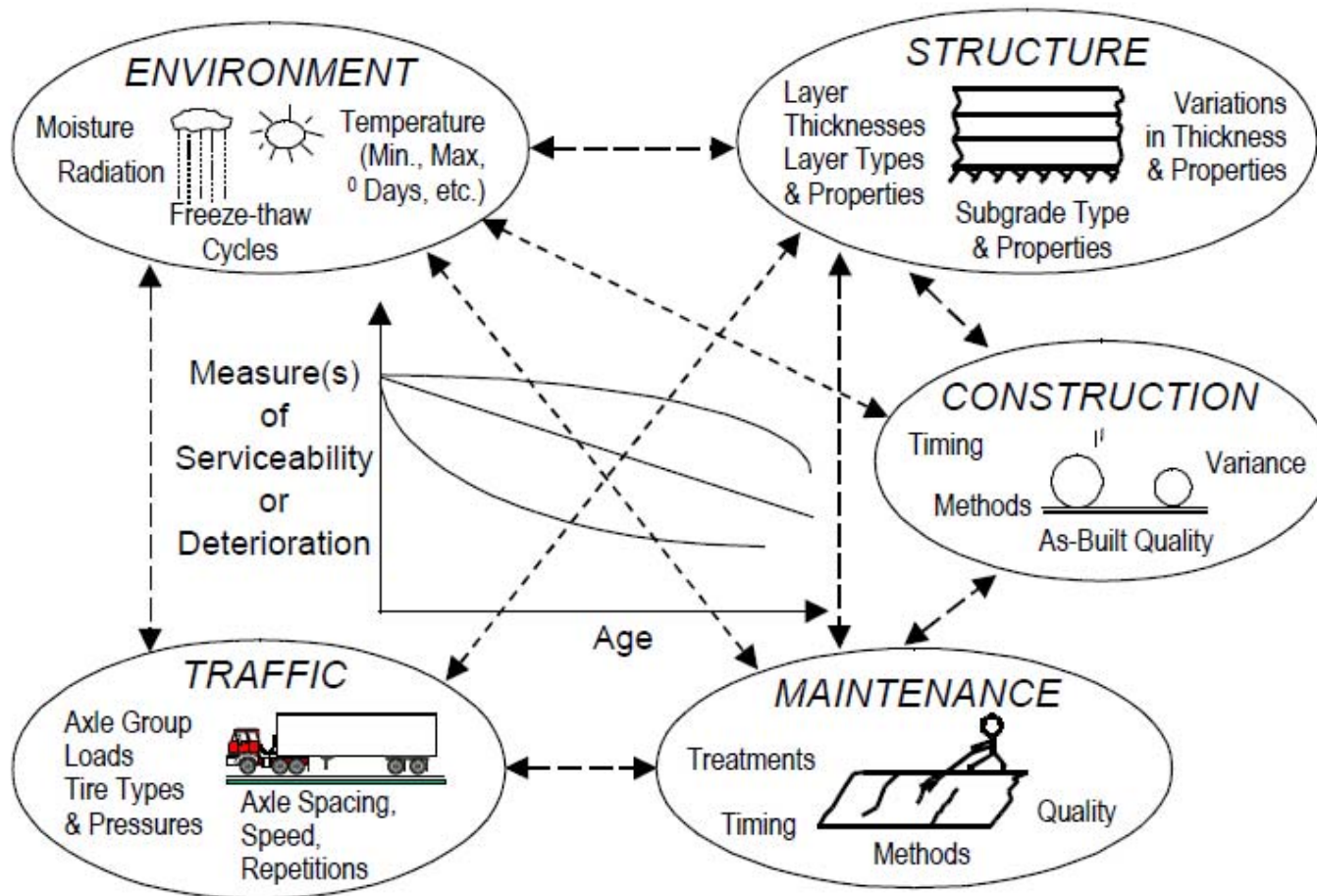


Figure 3 Factors affecting pavement performance

Haas, 2001

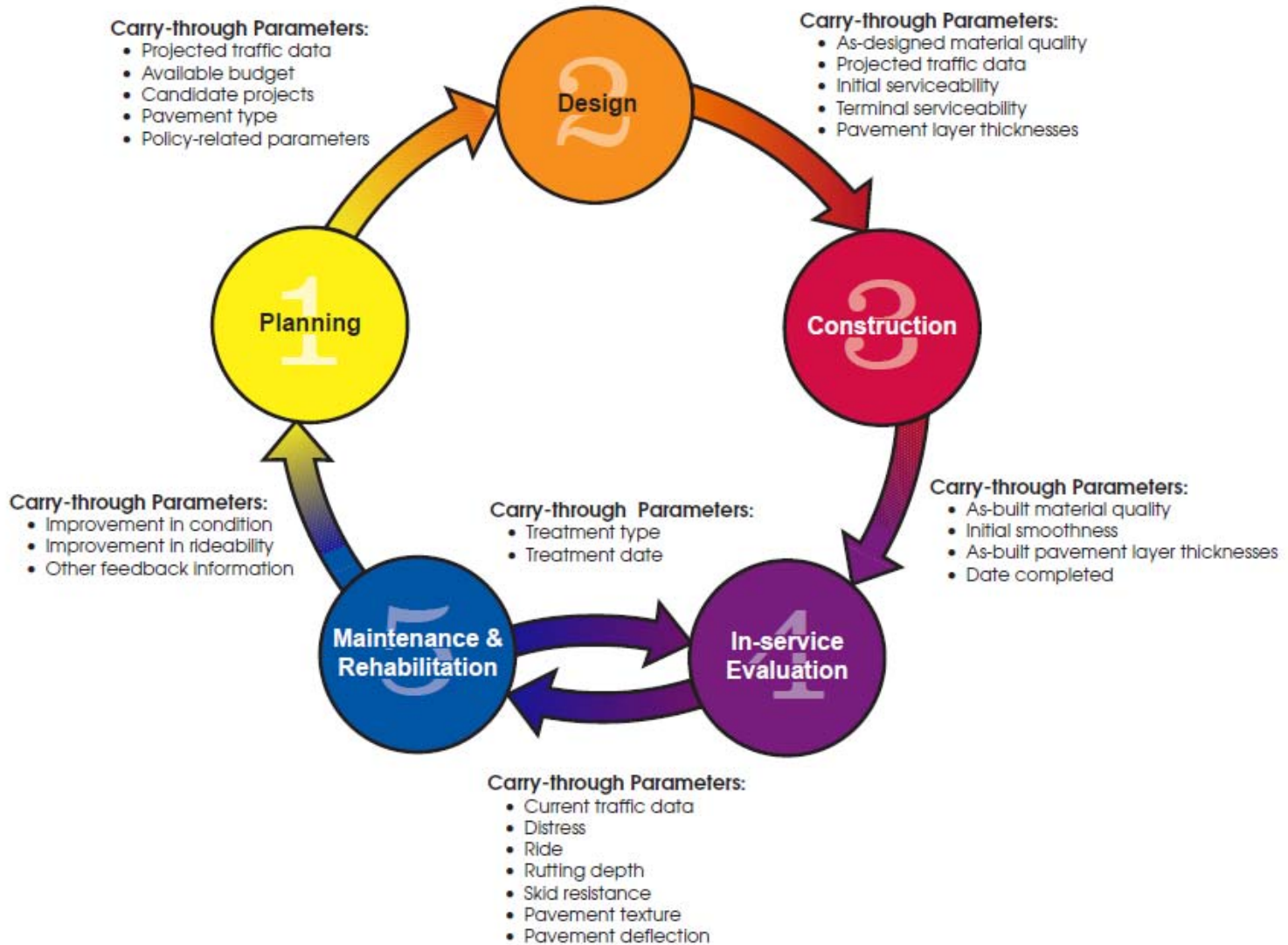


Figure 1. Conceptual Framework of the “Cradle-to-Grave” Pavement Monitoring Process

# 2008 - ?? What is the future for PMS?

- Integration with other infrastructure systems
- Use of Economic Performance Indicators
- Automated image interpretation
- LIDAR
- 3-d pavement surface interpretation
- PMS on i-Phone??
- ?????



# PMS Feedback Loop

## *Feedback Loop*

It is extremely important to continuously monitor, evaluate, and recalibrate a PMS using a feedback system. Feedback loops must be established within the pavement management process so that performance and repair cost data are constantly updated within the system; this process will improve the reliability of the PMS. In addition, the feedback process can be used to quantify the cost-effectiveness of various pavement repair techniques and to check the accuracy of design procedures. In most cases, feedback is a manual process.

**From WSDOT publication “Pavement Management Guide for Local Agencies”, 1997**



# Economic Performance Measures

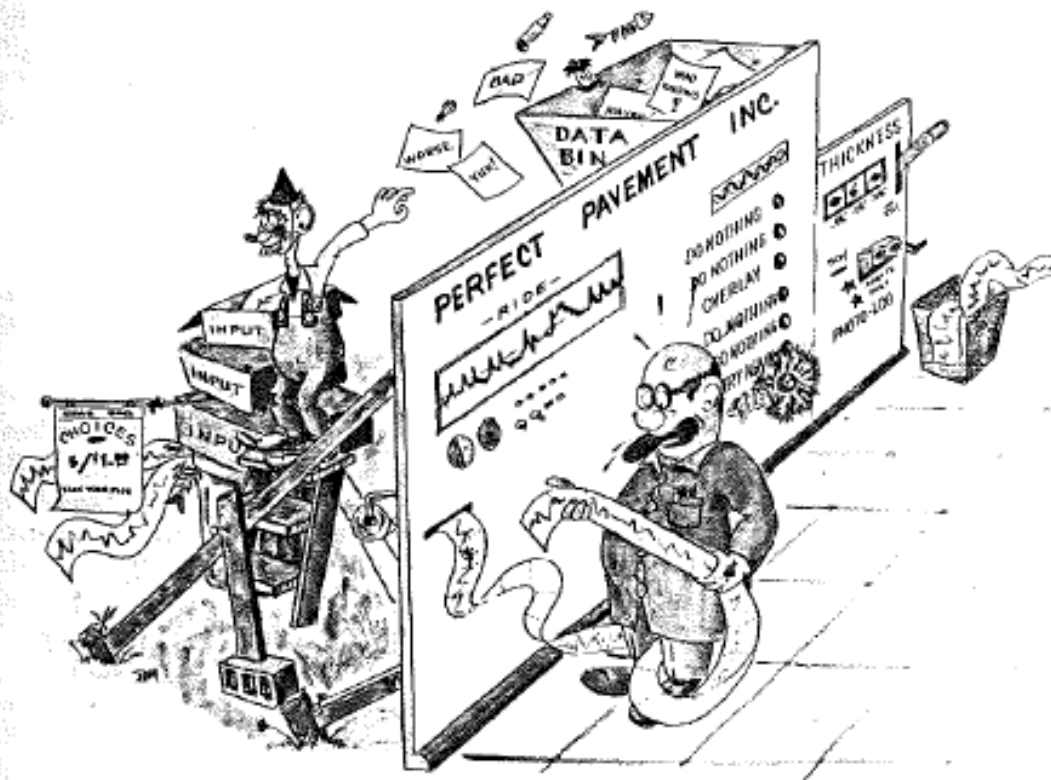
- Historical Annual Cost
  - EUAC (\$ / In-mi / year)
  - Assumes 4% discount rate
- ESAL Efficiency
  - Divide EUAC by average ESALs per lane per year
  - \$ / ESAL - mi



# What have we learned after 50 years?

- PMS is not difficult to design; it does take work to implement
- We need to learn more from our experiences
- A simple system that is implemented is much more beneficial than a complicated system that is difficult to implement





## Pavement Decision Criteria

Finn, et al, 1974





# Questions?



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