A Pavement Management Primer

Presented To: Graduate Transportation Seminar (TRANS 691)

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Learning Objectives

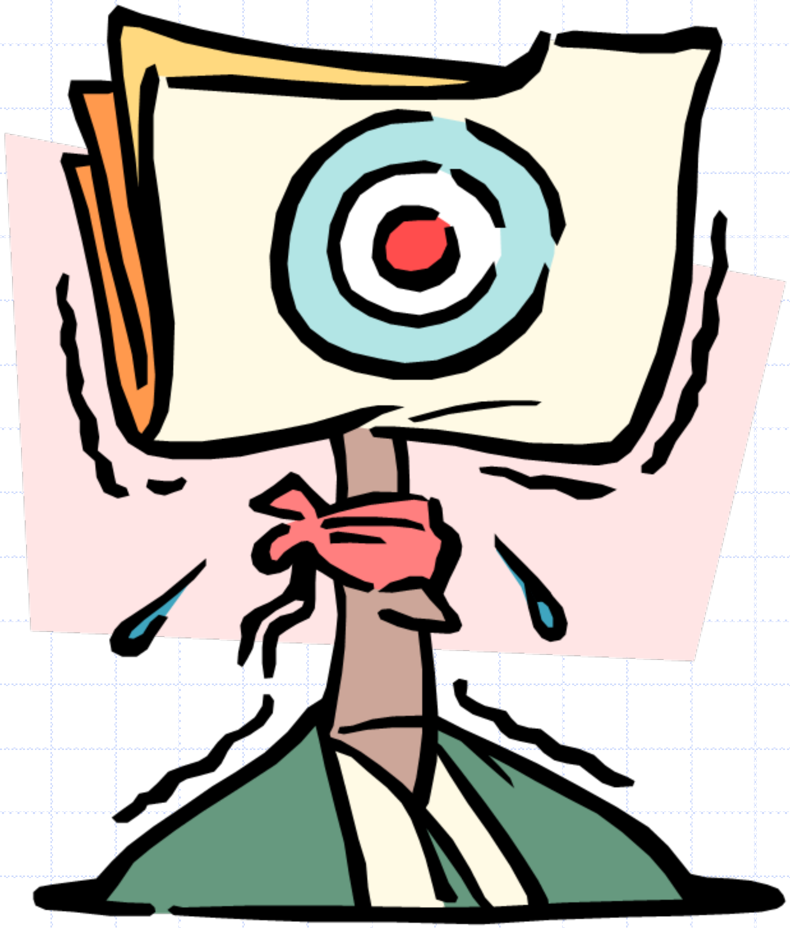
- Describe the components of a pavement management system
- Describe the types of models that are used in a pavement management system
- Describe the use of pavement management techniques in a transportation agency

Approach

- Introduce Pavement Management Conceptually
- Introduce the Components of a Pavement Management System
- Discuss Each Component in More Detail
- Illustrate the Ways Pavement Management Results Can Be Used

APPLIED PAVEMENT TECHNOLOGY

A Conceptual Approach to Pavement Management



Pavement Management Is...

- ...a management approach used by personnel to make cost-effective decisions about a road network.

AASHTO Pavement Management Guide (2001)

A Pavement Management System Is...

- ...a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time.

AASHTO *Guide for Design of Pavement Structures (1993)*

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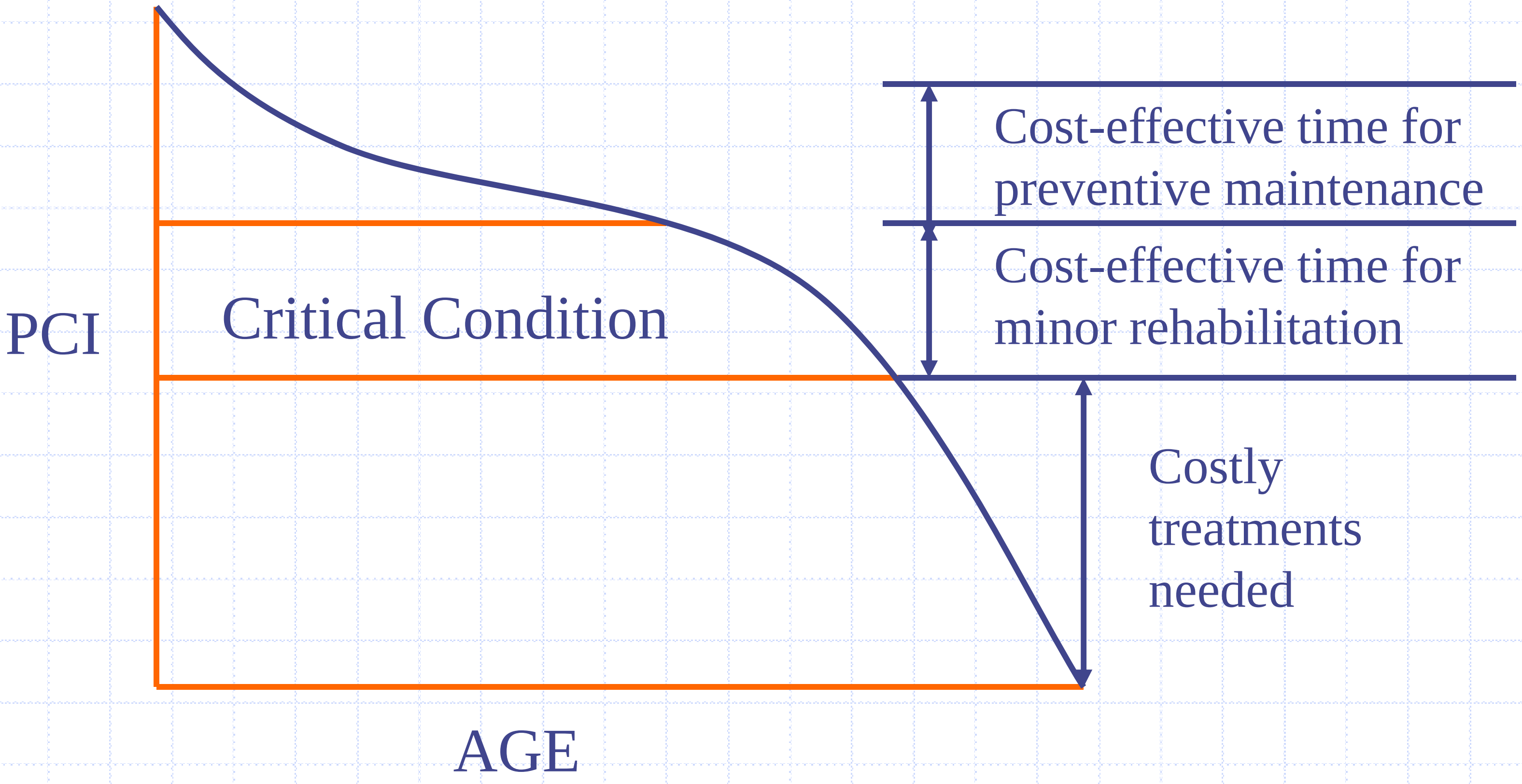
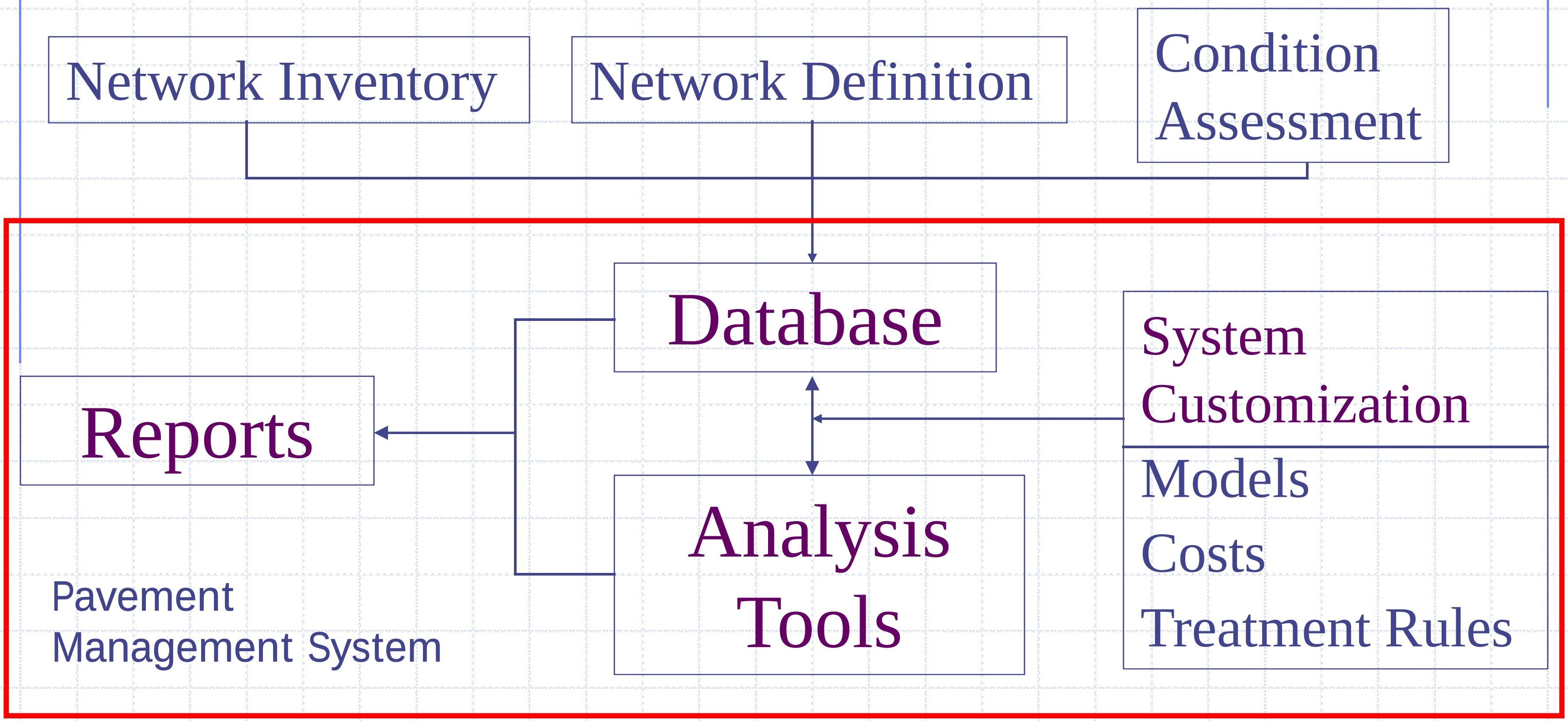
Use of Pavement Management

- Identify and prioritize maintenance and rehabilitation needs
  - Select projects and treatments on an objective, rational basis
- Assist agencies in determining cost-effective treatment strategies
  - Allocate funds so an agency can get the most “bang for the buck”
  - Demonstrate impacts of alternate strategies

Managing Pavement Deterioration



Pavement Management Components



Network Inventory

- Type of Data to be Collected
  - Physical characteristics
  - Construction and maintenance history
  - Traffic levels
  - Climate information
  - Soils information
- Minimal Amount of Information Required
  - Surface type
  - Last construction date
  - Physical dimensions

Network Definition

- Used to link network inventory information to a physical location in the field
- Determine section boundaries by evaluating the road characteristics. Sections should be similar in terms of surface type, structure, and traffic
- Identify beginning and end points and width

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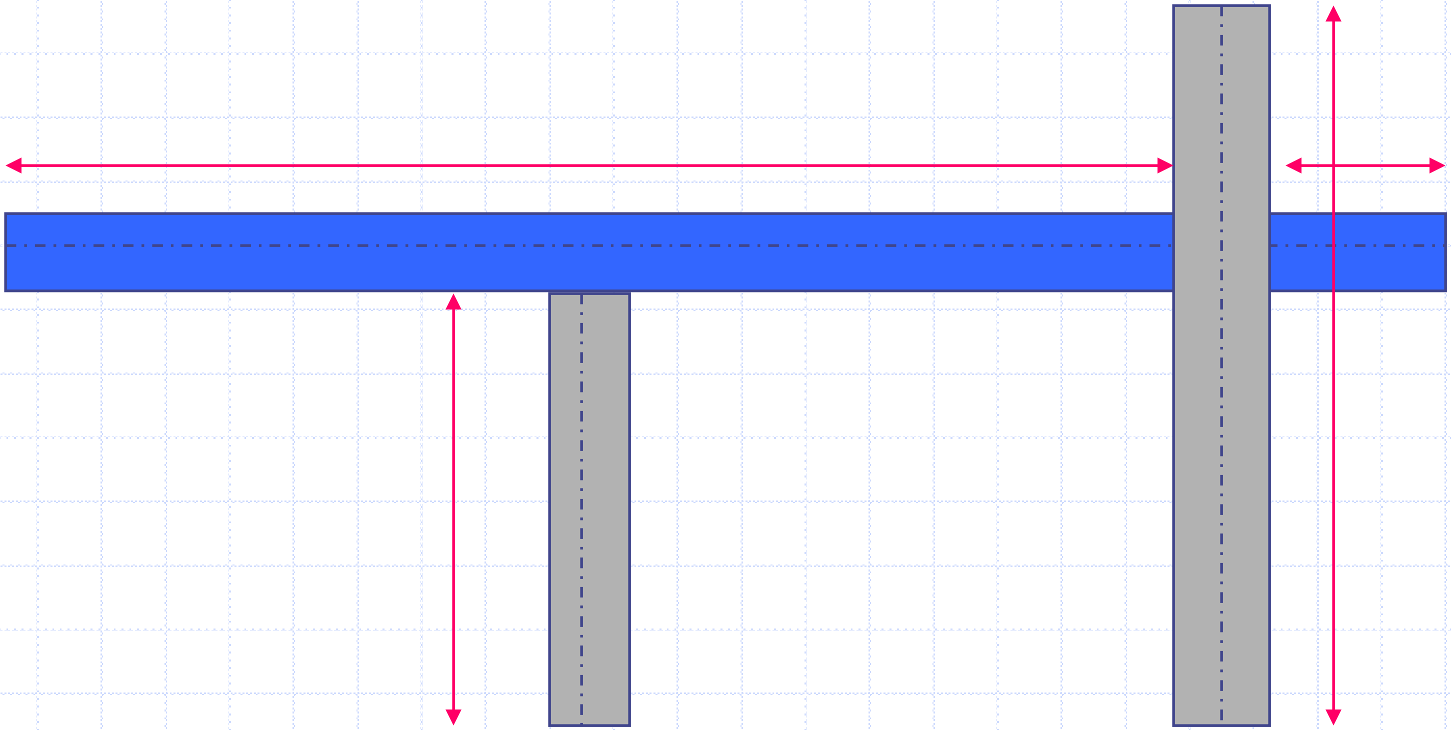
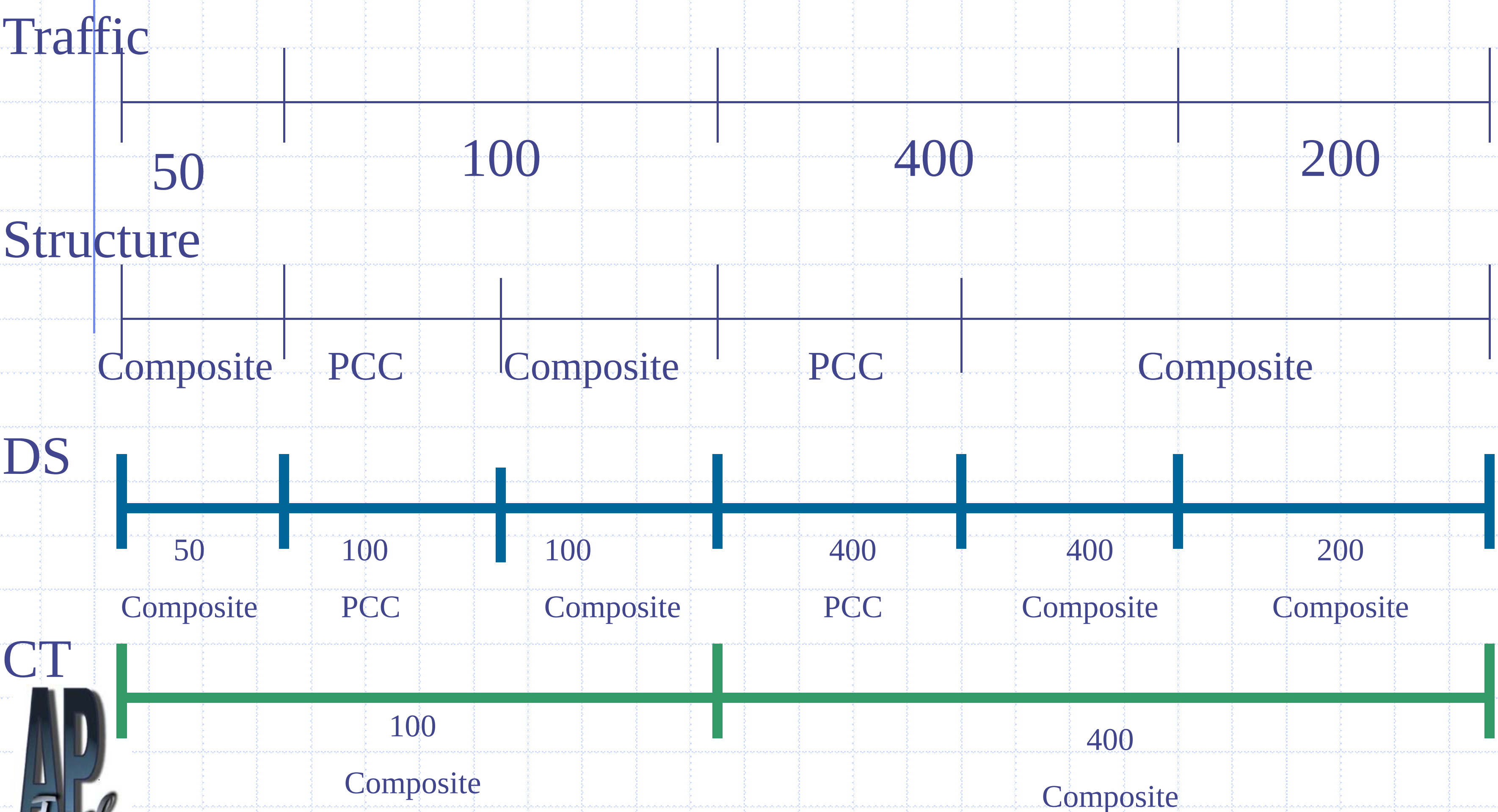
Network Definition – Local Agencies

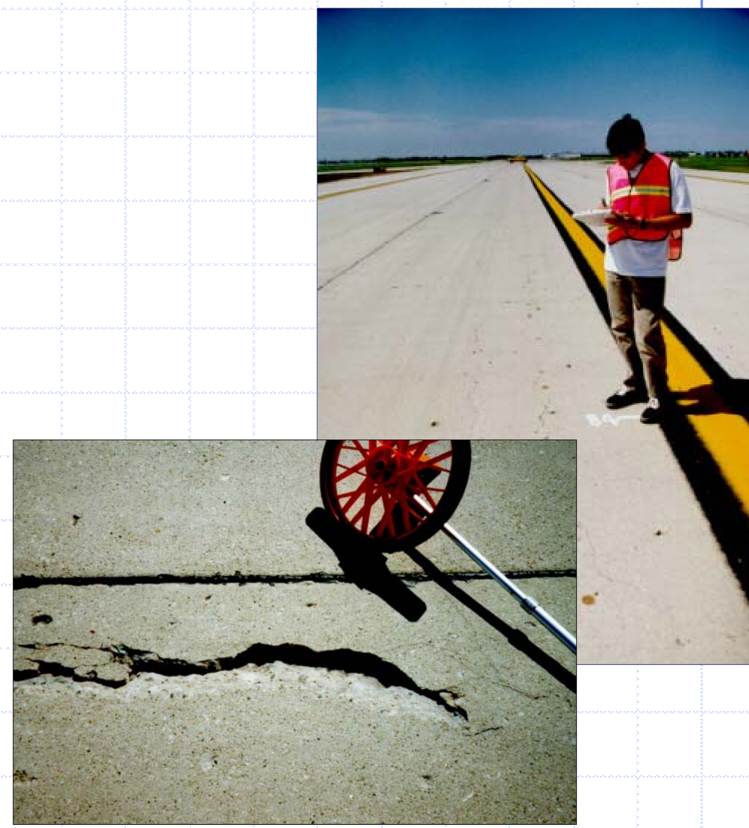


Dynamic Segmentation and Concurrent Transformation



Condition Assessment

- All system recommendations are based on the current and predicted conditions of the sections in your network
- Therefore, the assessment of current condition MUST be objective and repeatable
- BUT, it must also match available resources



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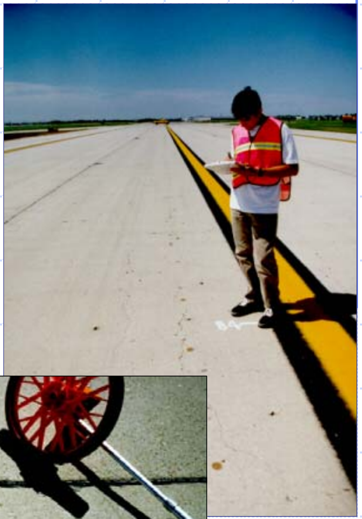
Types of Pavement Condition Data Collected

- Surface distress (cracking, surface deform
- Roughness (ride)
- Faulting
- Rutting
- Skid resistance
- Structure (pavement strength and deflection)

Approaches to Collecting Pavement Condition Data

- Manual
- Semi-automated
- Automated





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Condition Indices

- Individual Indices
  - Ride Index
  - Structural Index
  - Cracking Index
- Composite Index
  - 40% Ride + 40% Structural + 20% Cracking
  - Σ (Deduct points associated with a distress type, severity, and extent combinations)

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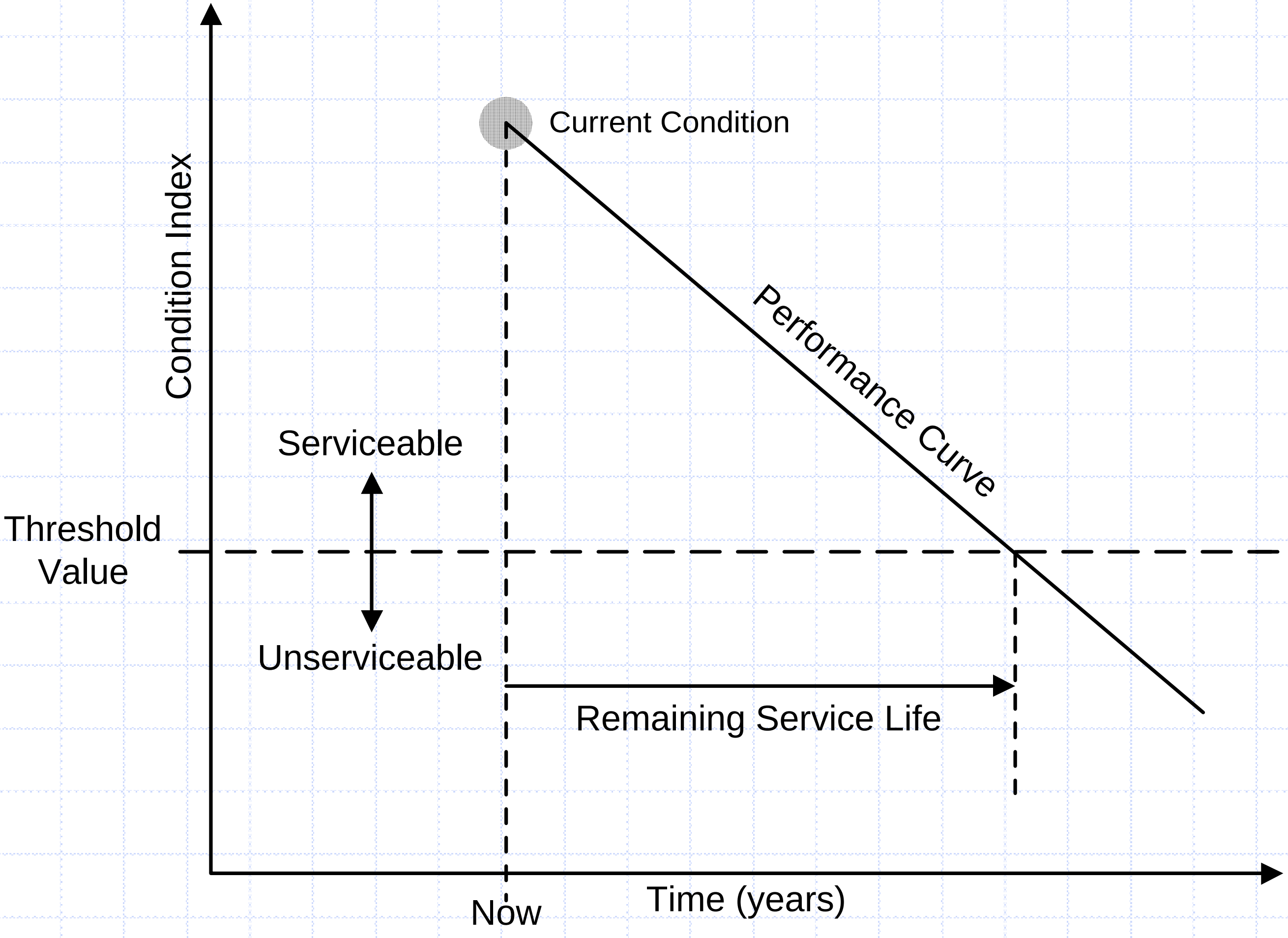
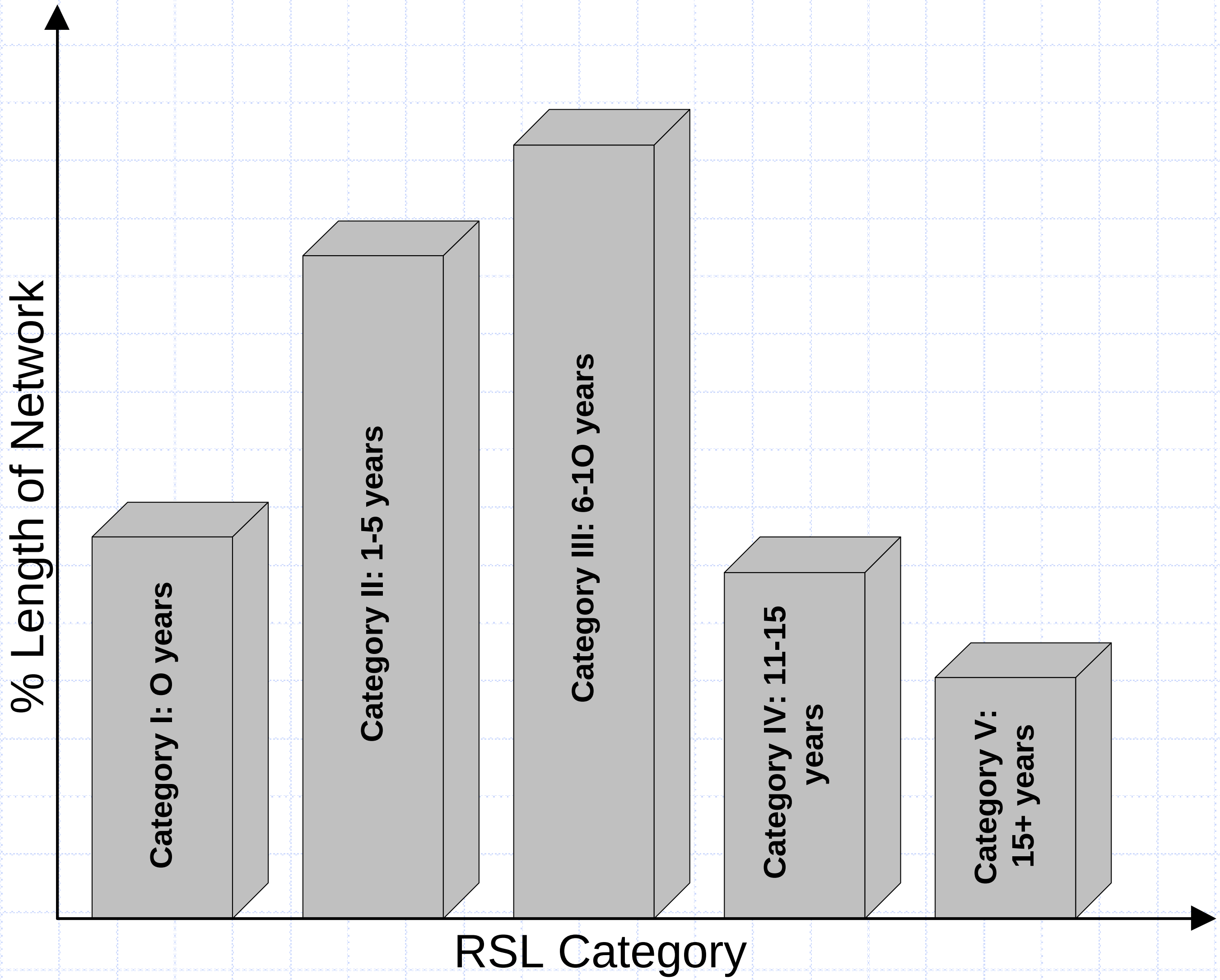
RSL Calculation



RSL Distribution



Database

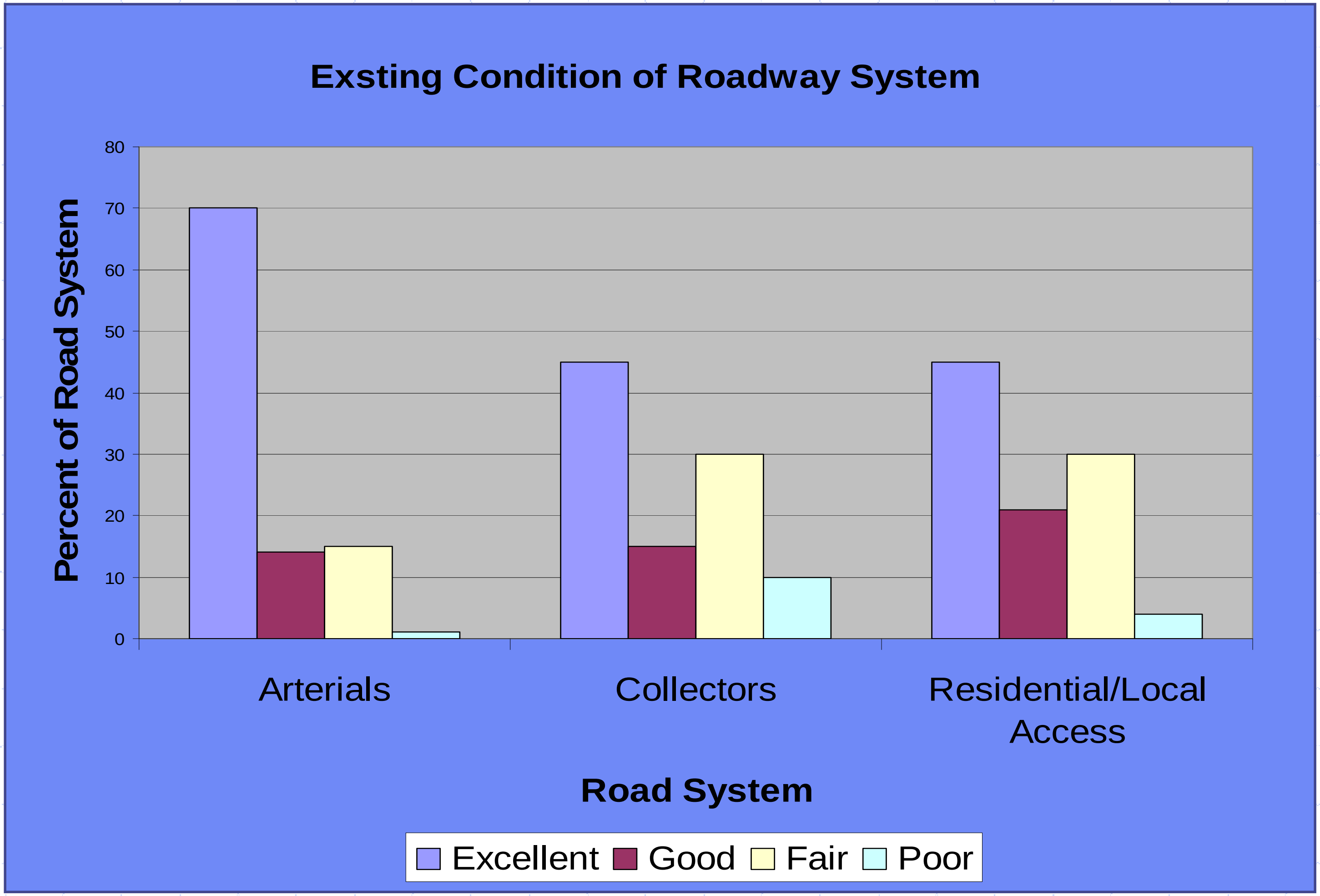
- Inventory Data
- Condition Data
- Record Retrieval and Reporting

Capabilities Once The Database Is Established

- Inventory reports
- Condition ratings
  - By functional classification
  - By surface type
- Pavement distress data analysis
  - Overall condition
  - Rate of deterioration
  - Cause of deterioration
- Ranked lists of road needs
  - Worst first or weighted rankings

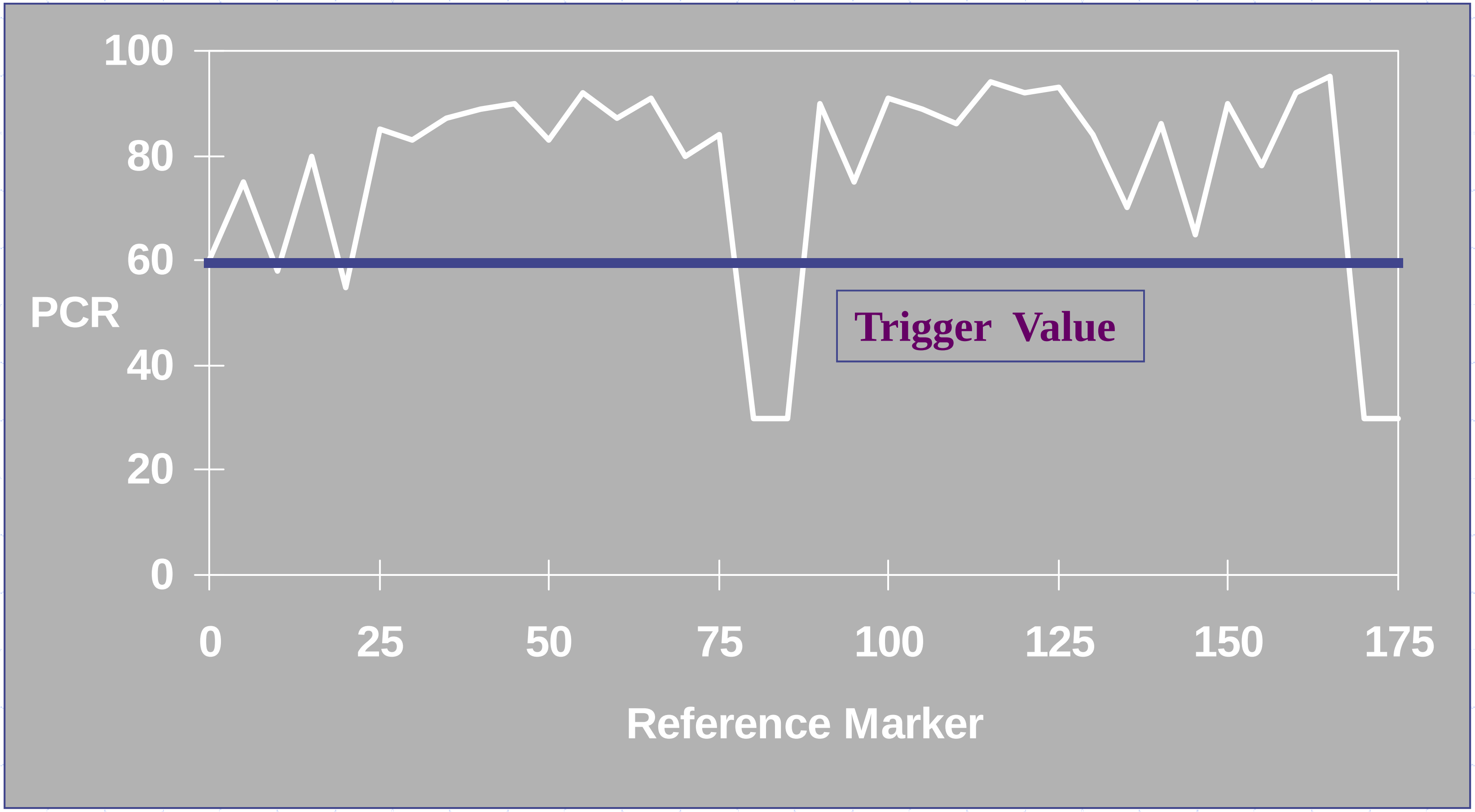
APPLIED PAVEMENT TECHNOLOGY

Condition Summary on a Network Basis

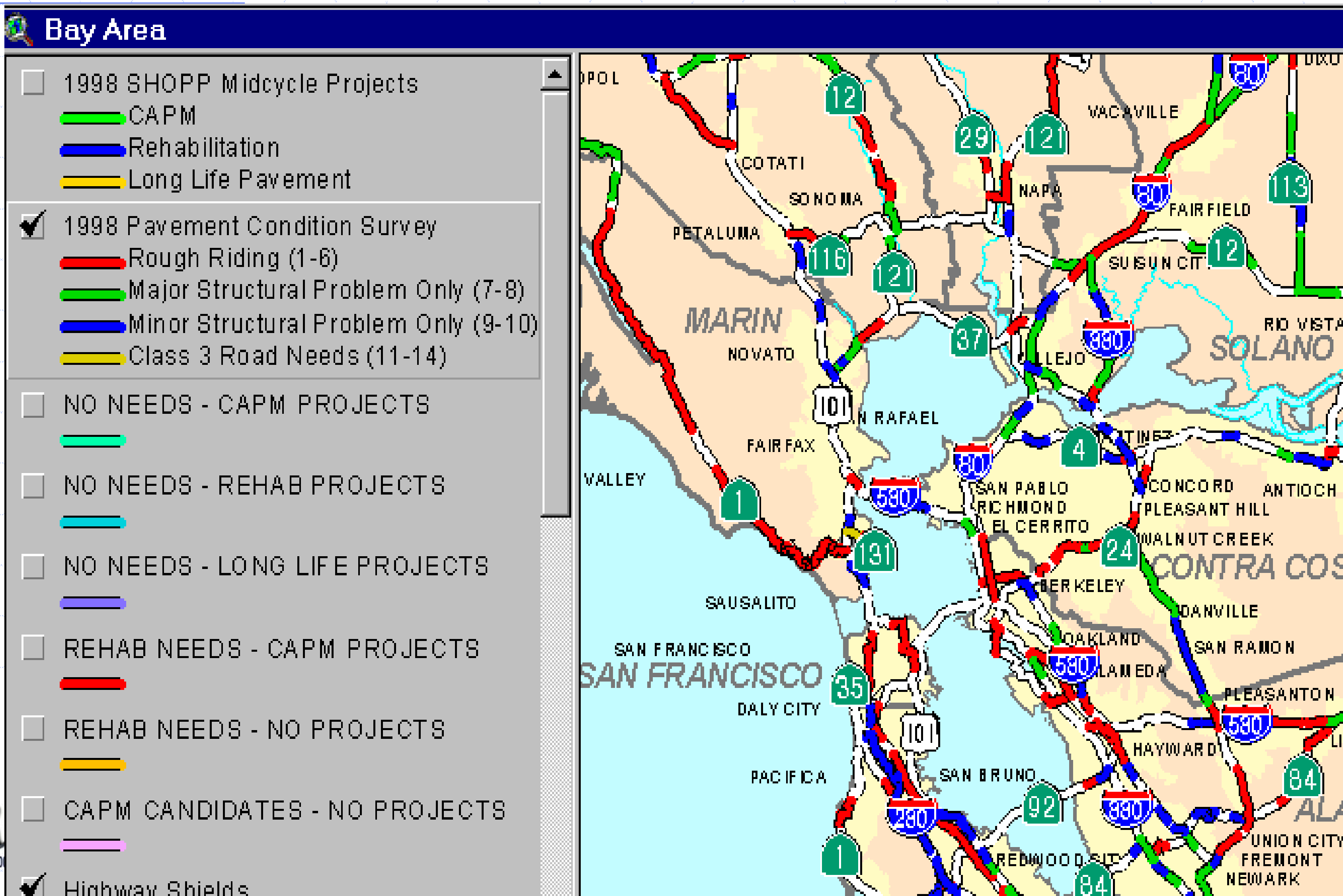


Condition Summary - By Route

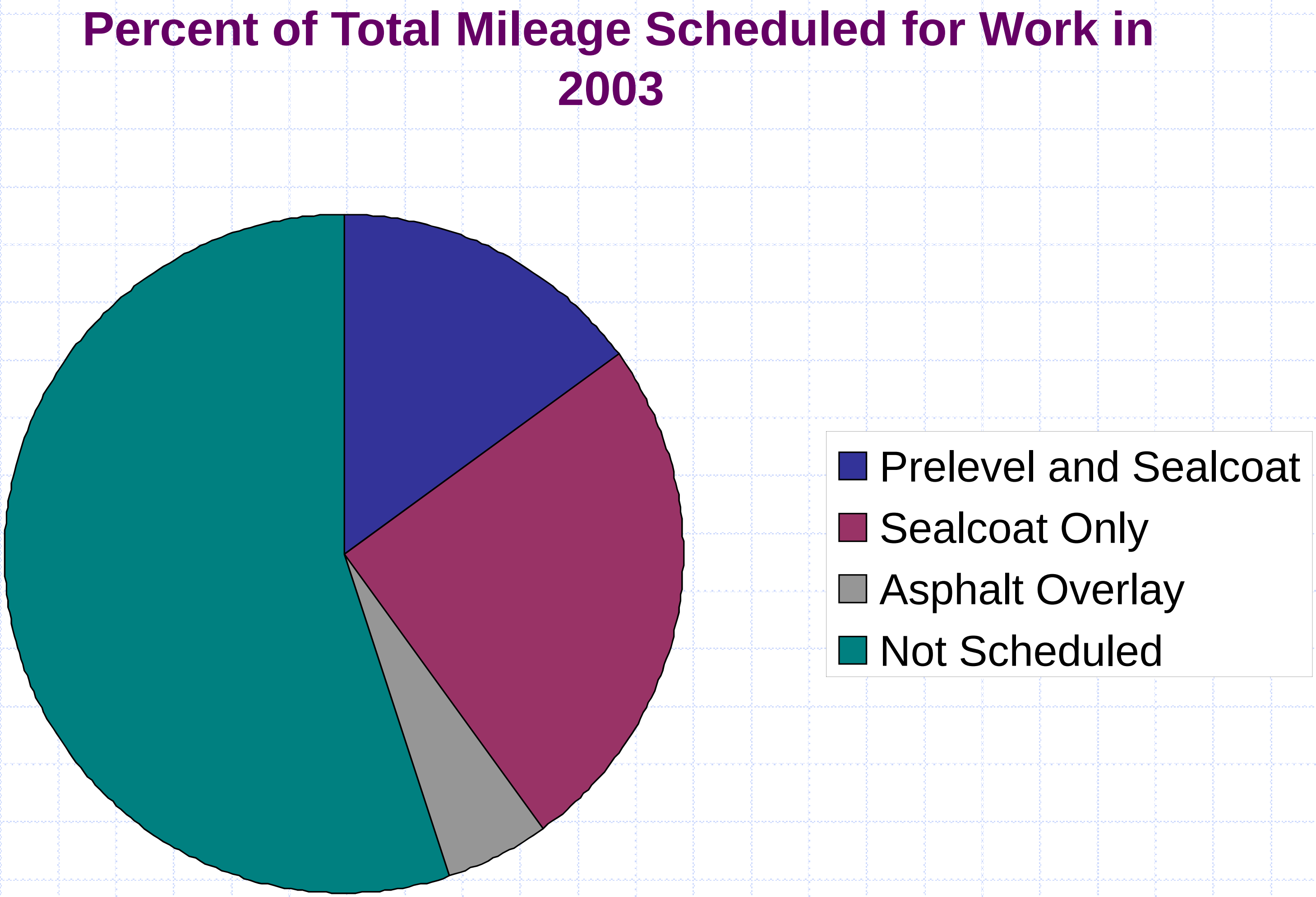
PCR Values for State Route 286 Eastbound



Condition Reports Through a Map Link



Work Type Summary



Building From a Database System

- To develop multi-year programs,
- To compare different options,
- To predict future conditions,

- You need a pavement management system that includes analysis models and multi-year programming capabilities

Analysis Models

- Pavement performance prediction models
- Treatment rules
  - When should a treatment be considered feasible?
  - What happens after the treatment is applied?
- Cost models
  - Budgets
  - Treatment cost models

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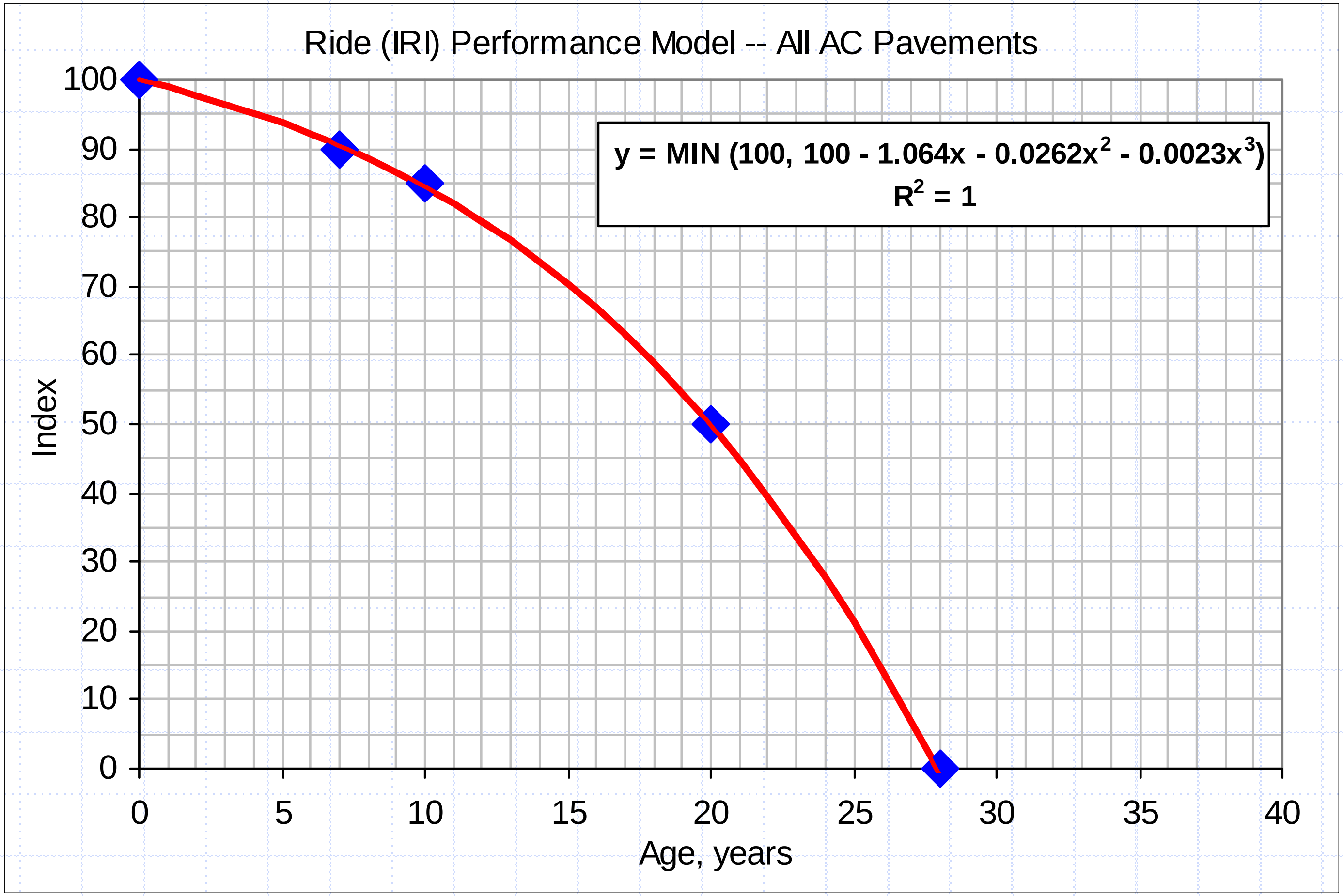
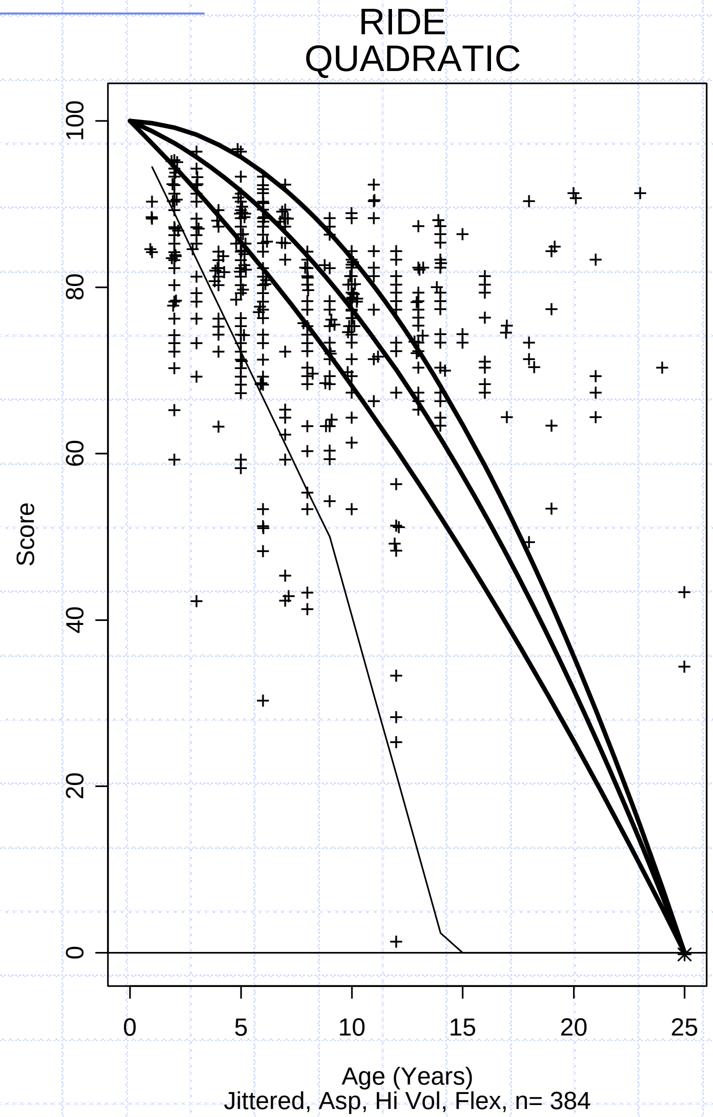
Pavement Performance Models

- Group pavements by similar features (develop a family)
- Plot all condition and age (traffic) data for the sections in the family
- Use statistics to determine best fit curve through data
- If no data are available, use expert opinion to develop model

Expert Model



Performance Model Using Actual Data



Date of Analysis: Fri Sep 6 09:34:35 2002
Family: Asp, Hi Vol, Flex
Index: RIDE
Year(s): 2001
Model Type: QUADRATIC
Analysis Method: GQ
Forced Endpoint: 25

25TH PERCENTILE
Coefficient Estimates:

	Value	Std. Error	t value	Pr(>|t|)
age	-2.64123	0.71100	-3.71483	0.00114
I(age^2)	-0.05435	0.02844	NA	NA

R-Squared = 0.059

50TH PERCENTILE
Coefficient Estimates:

	Value	Std. Error	t value	Pr(>|t|)
age	-1.10583	0.60599	-1.82484	0.08104
I(age^2)	-0.11577	0.02424	NA	NA

R-Squared = 0.238

75TH PERCENTILE
Coefficient Estimates:

	Value	Std. Error	t value	Pr(>|t|)
age	-0.08989	0.57306	-0.15686	0.87673
I(age^2)	-0.15640	0.02292	NA	NA

R-Squared = 0.35

R-square of NaN may occur when too many data points are at the maximum value

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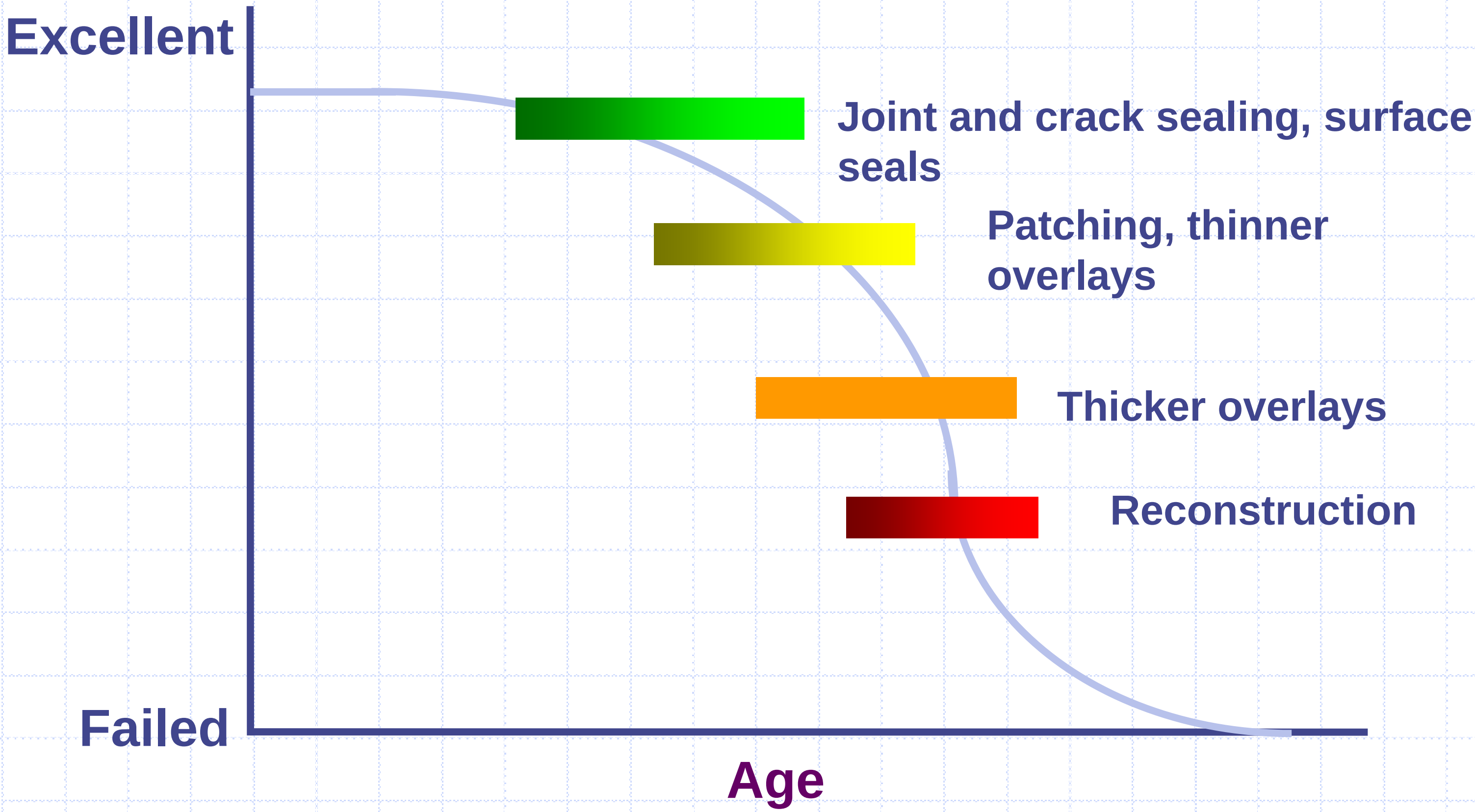
Goodness-of-fit for the EXPERT CURVE relative to the 50th percentile = 0.302

If less than 1, the 50th percentile fit is better

Treatment Rules: Type, Timing, Cost

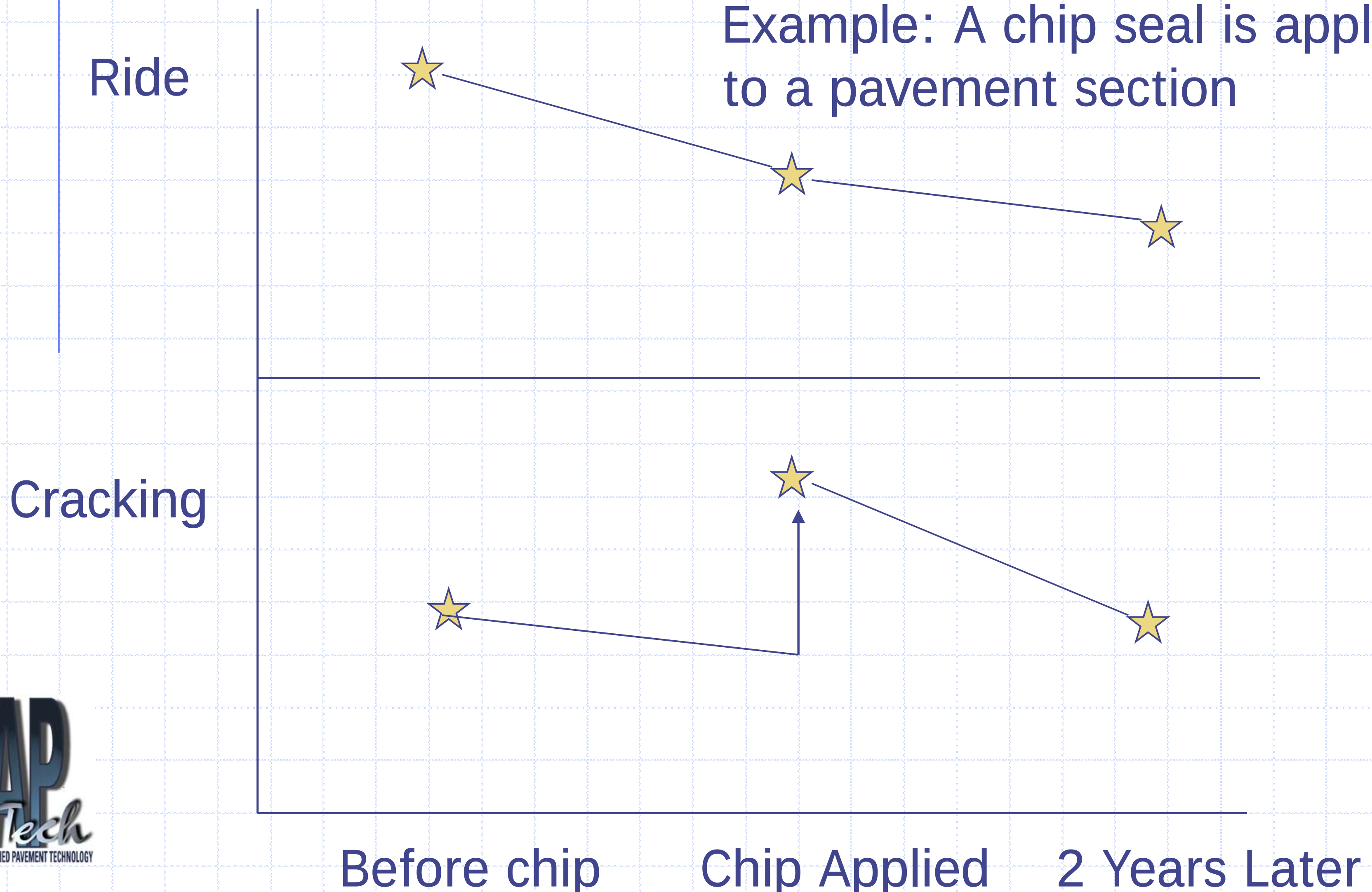


Treatment Impact Rules

- What happens to the condition of a section after the treatment has been applied?
  - Do conditions return to a perfect score? (Is the distress eliminated?)
  - Does the severity of the distress change?
  - Does it deteriorate the same way it did before the treatment was applied?

Modeling Treatment Impacts

Example: A chip seal is applied to a pavement section



Cost Models

- Treatment Costs
  - Based on recent bid documents
  - May vary based on certain factors (location, street network, and so on)
- Budgets
  - Funds available for each analysis year
  - Some agencies have separate budgets for maintenance and rehabilitation activities

Analysis Approaches

- Once needs are identified, there must be a way of prioritizing the list and determining which projects should be funded
- Three approaches
  - Ranking
  - Multi-Year Prioritization
  - Optimization

Ranking

- Most simplistic of the approaches
- Traditionally used in worst-first scenarios
- Often doesn’t use predictions of condition
- In most cases, alternate programs are not considered

Ranking Example

Section	Condition Level	Treatment	Cost (mil)
67A	67	Minor	1
67B	82	PM	0.5
67C	52	Major	3
14A	71	Minor	2
14B	74	Minor	1.5
Univ1	85	PM	0.5

Results for $4 Million Budget

Section ID	Ranking	Condition Level	Treatment	Cost ($millions)
67C	1	52	Major	3
67A	2	67	Minor	1
14A	3	71	Minor	2
14B	4	74	Minor	1.5
67B	5	82	Prev. Maint.	0.5
Univ1	6	85	Prev. Maint.	0.5

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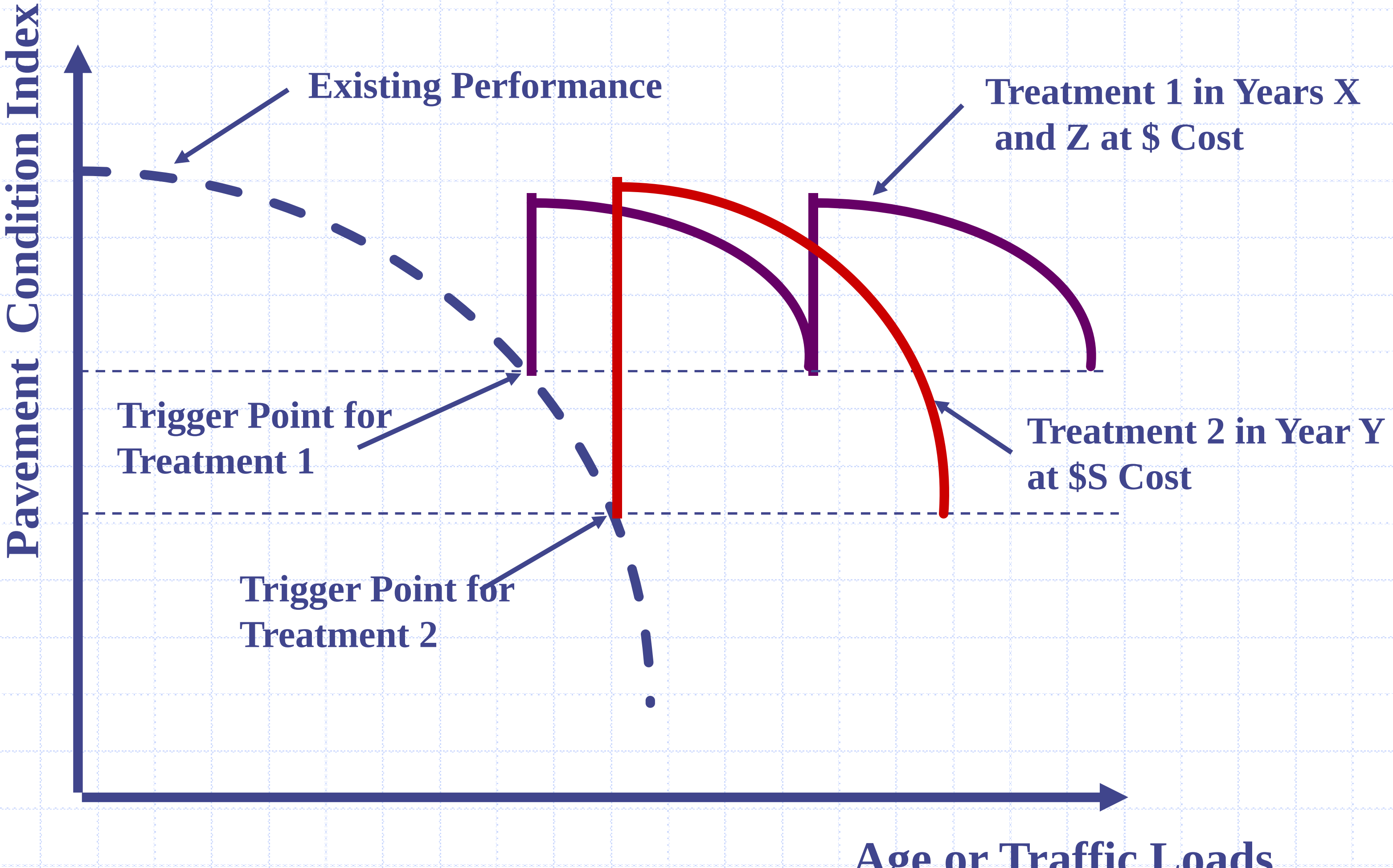
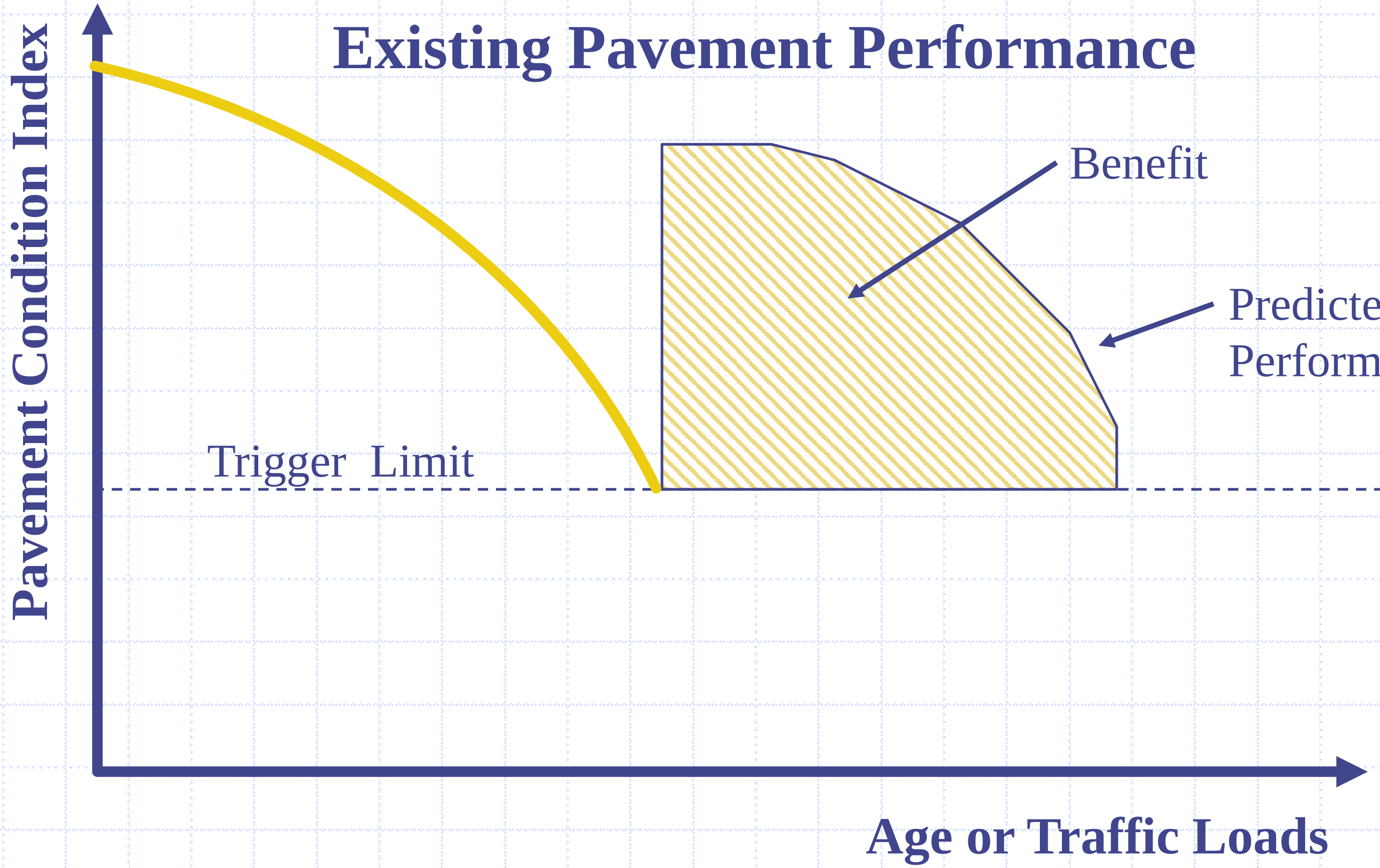
Multi-Year Prioritization

- Moderate level of sophistication
- Allows multiple alternatives to be considered during a multi-year program
- Fairly easy to explain and justify recommendations
- Results in “near optimal” solutions

Treatment Options in MYP



Benefit/Effectiveness Calculation



Optimization

- Most sophisticated approach
- Only used by a few states
- Two step process
  - First, set optimal program strategy recommendations
  - Second, select projects to fit strategy

Markov Transition Probability Matrix

Current State	Future State			
	1	2	3	4
1	0.2	0.4	0.3	0.1
2		0.2	0.6	0.2
3		0.1	0.3	0.6
4			0.1	0.9

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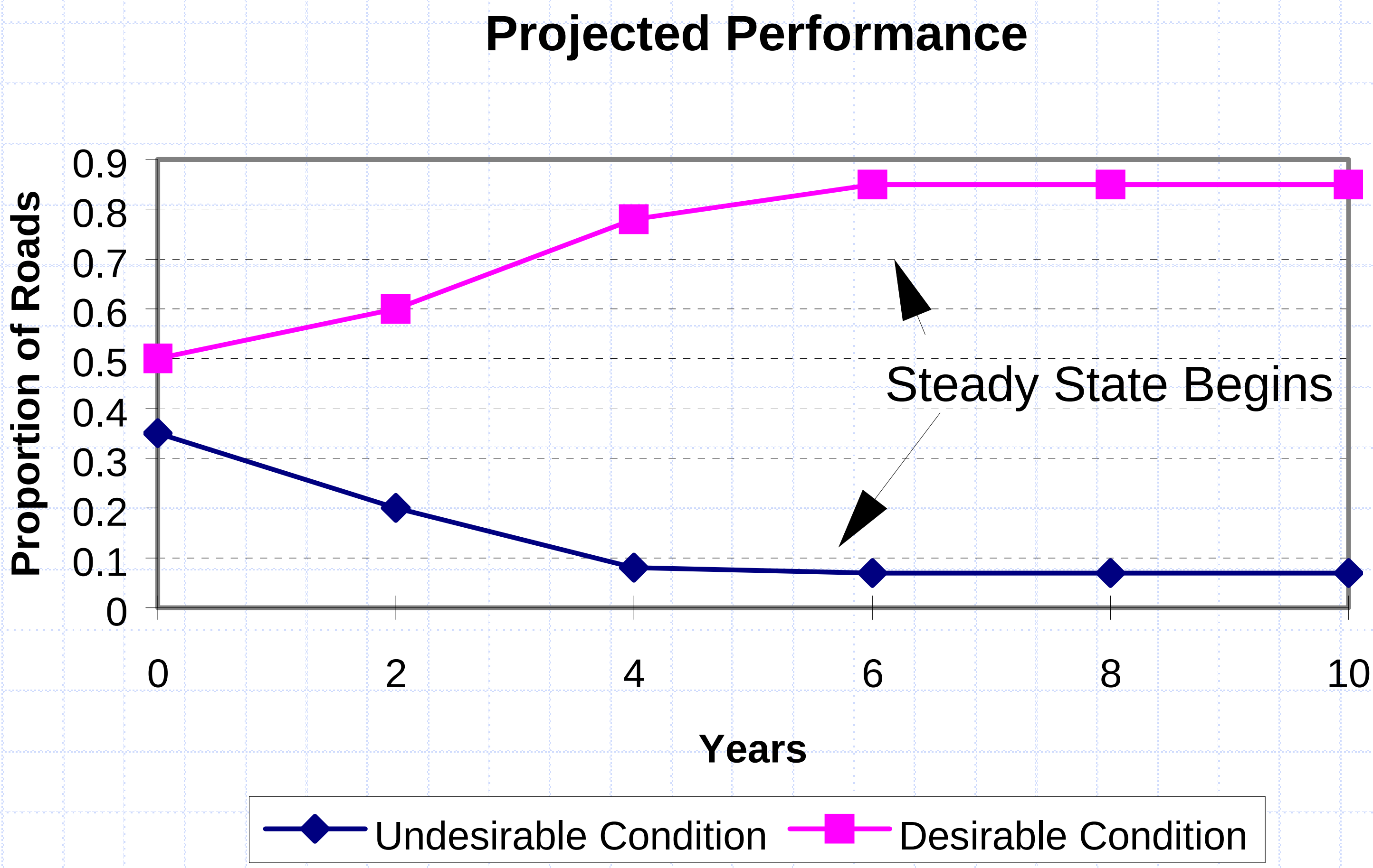
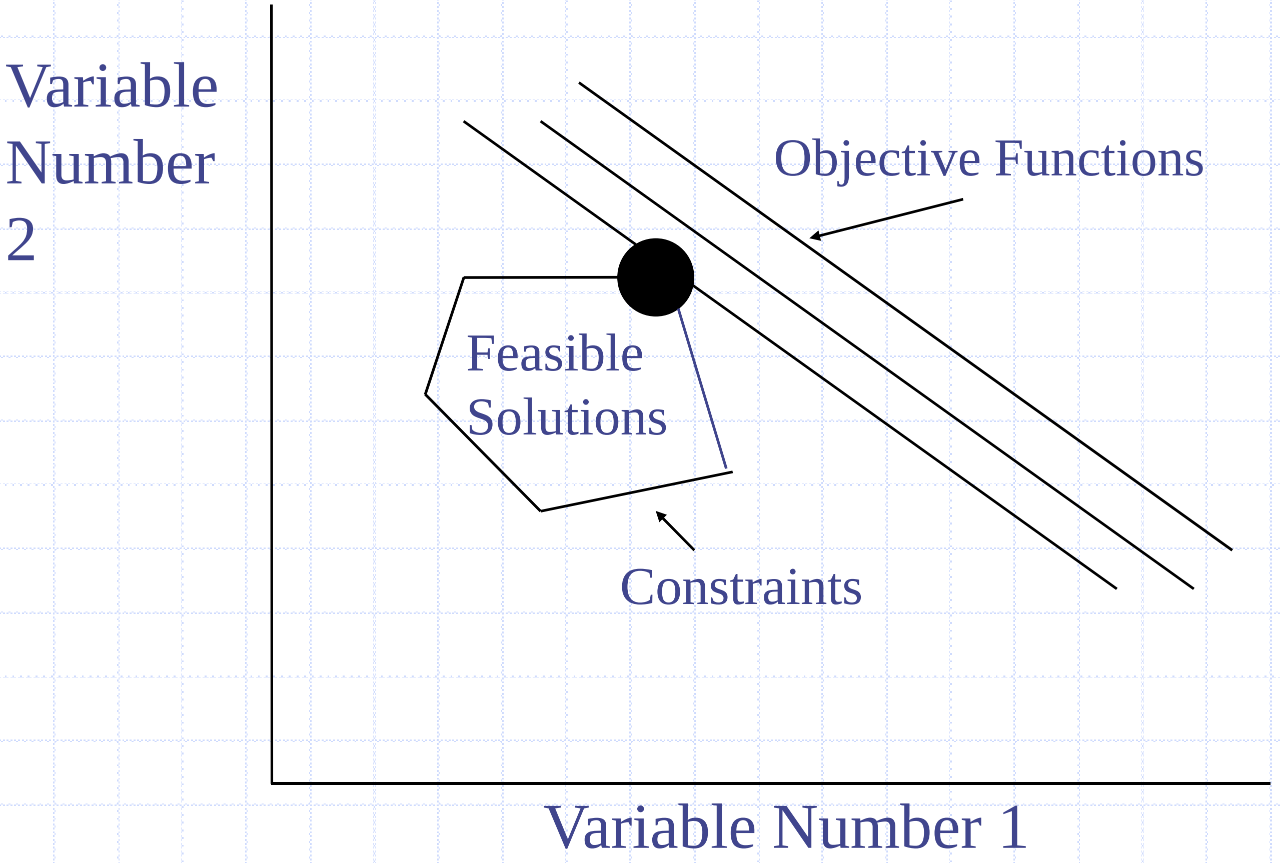
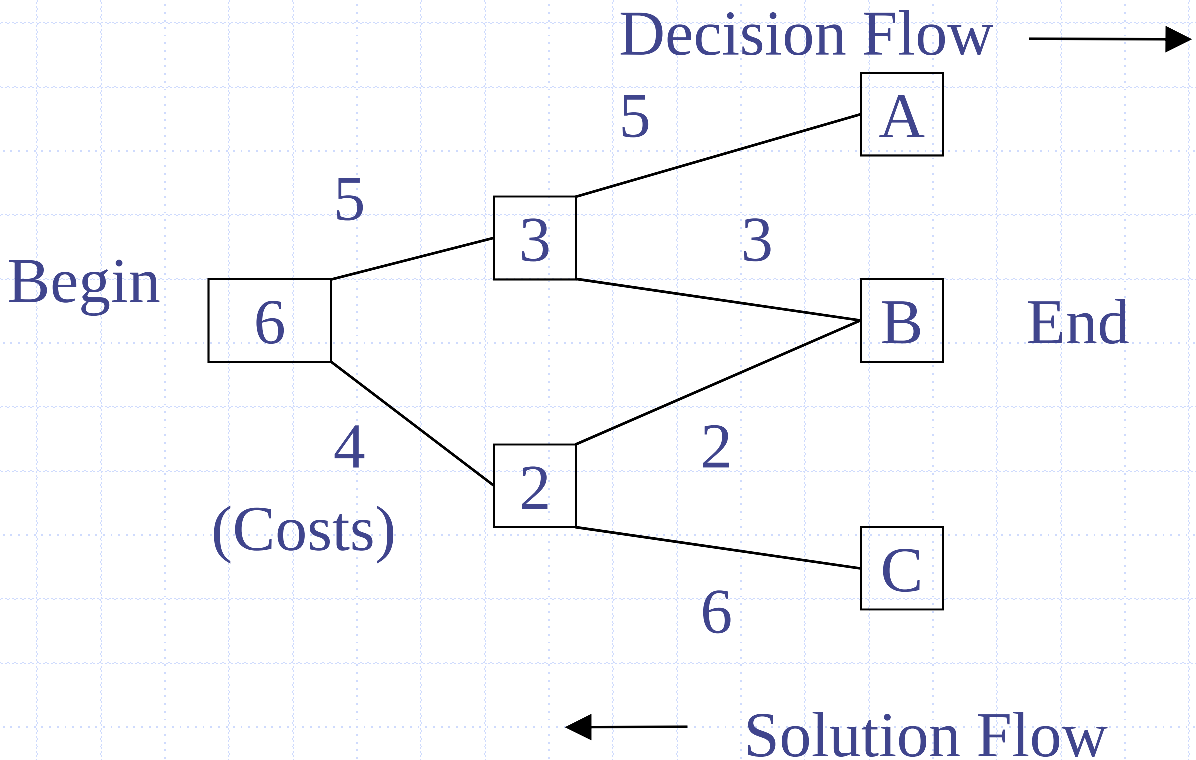
Example Network Performance



Linear Programming



Dynamic Programming



The Use of Pavement Management Tools

- Identify and prioritize maintenance and rehabilitation needs
- Evaluate the impact of various programs through a comparison of conditions, backlog, or another measure
- Establishing pavement condition targets
- Setting budget needs

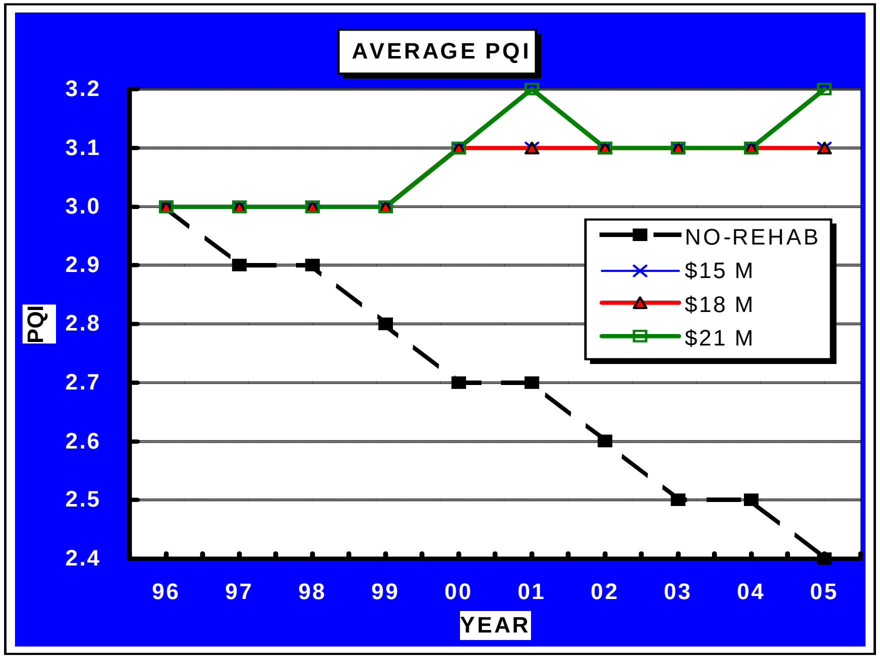
Impact Analysis

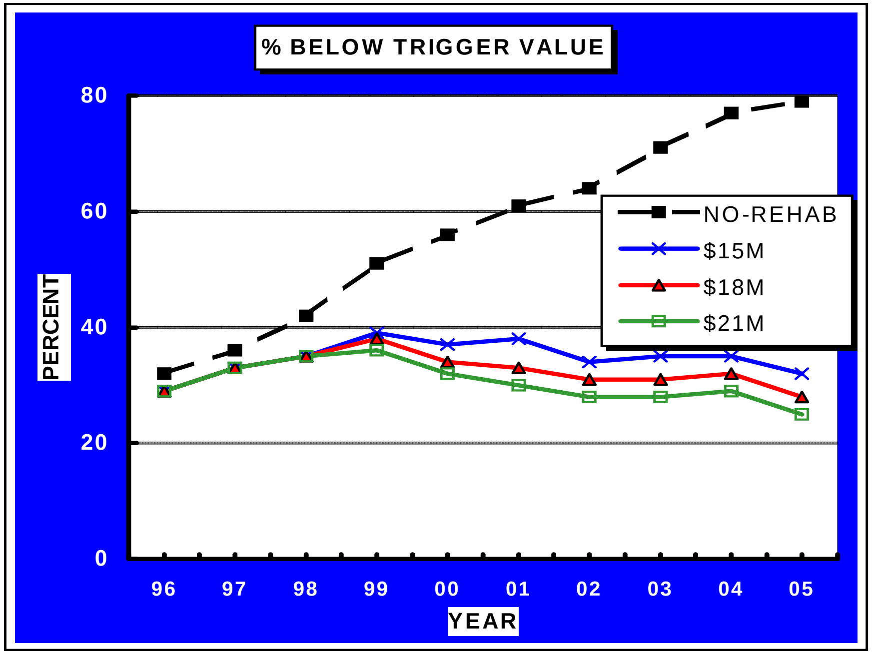
NETWORK LEVEL PERFORMANCE BASED ON 4 FUNDING SCENARIOS

WILLMAR DISTRICT — PAVEMENT MANAGEMENT

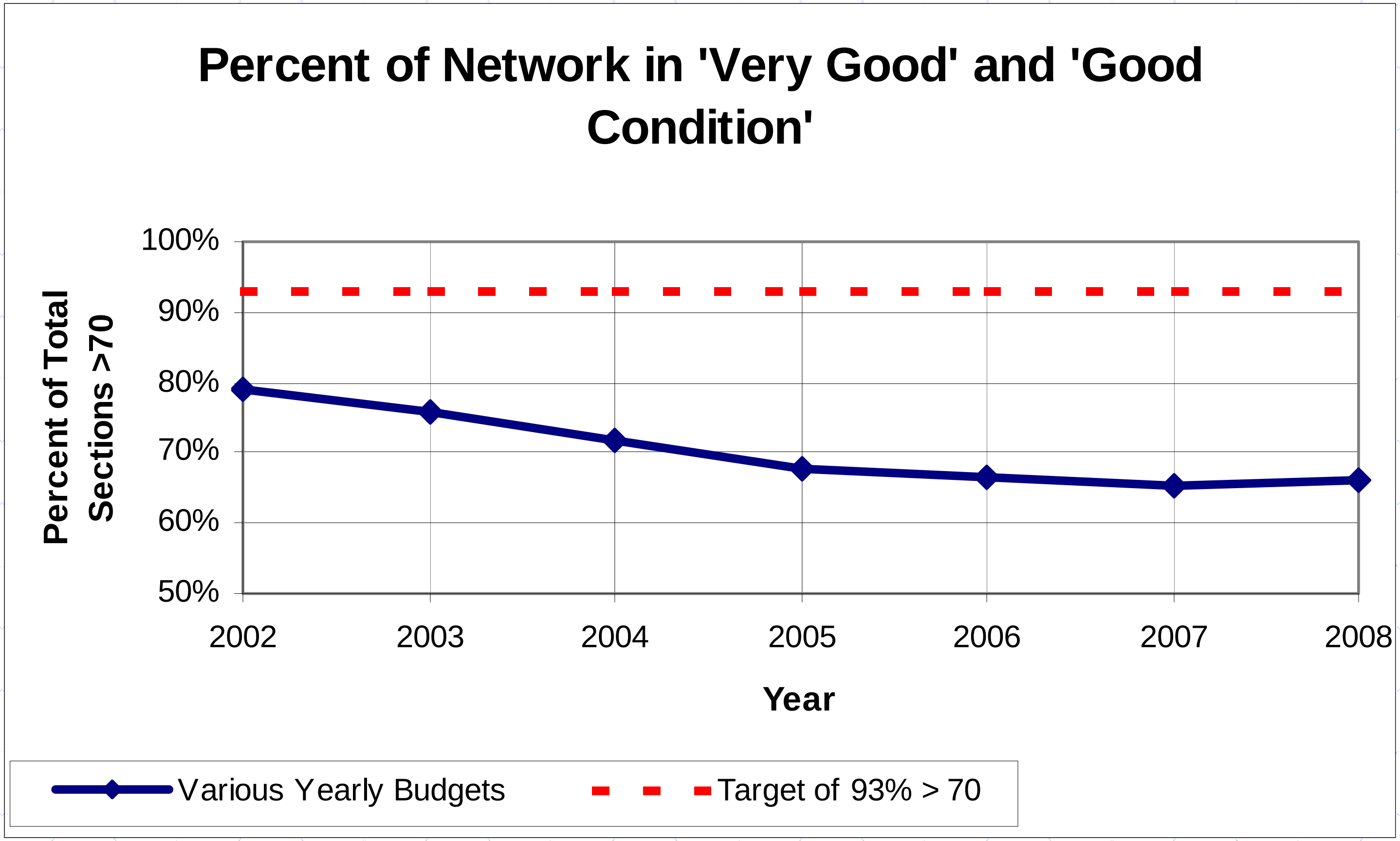
ALL SCENARIOS BASED ON USING PROGRAMMED PROJECTS — OCTOBER, 1995

		YEAR									
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AVERAGE PQI	NO-REHAB	3.0	2.9	2.9	2.8	2.7	2.7	2.6	2.5	2.5	2.4
	$15 MILLION	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.1	3.1
	$18 MILLION	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.1	3.1
	$21 MILLION	3.0	3.0	3.0	3.0	3.1	3.2	3.1	3.1	3.1	3.2
% PQI < TRIGGER	NO-REHAB	32	36	42	51	56	61	64	71	77	79
	$15 MILLION	29	33	35	39	37	38	34	35	35	32
	$18 MILLION	29	33	35	38	34	33	31	31	32	28
	$21 MILLION	29	33	35	36	32	30	28	28	29	25

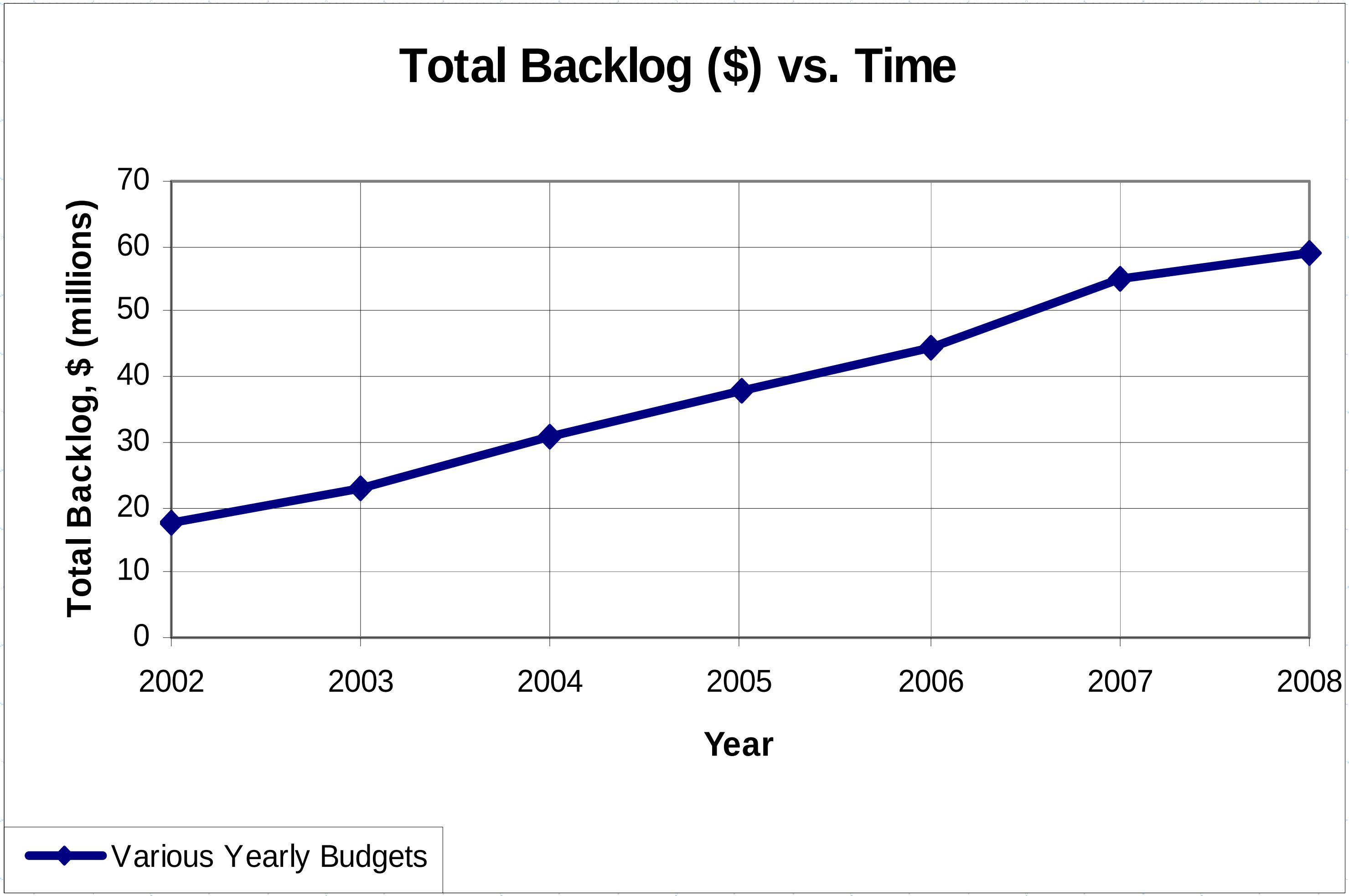




Goal Setting and Measuring



Backlogged Needs



Communicating Budget Needs

GEORGIA AVIATION NEWS
A Newsletter of the Georgia Department of Transportation
April 1998 Volume I No. 1

Airport Pavement Management Study Underway

The Georgia Department of Transportation's (GDOT) Aviation Programs, with funding assistance from the Federal Aviation Administration (FAA), has initiated a statewide airport Pavement Management Study.

This study will form an airfield pavement database for all 94 of Georgia's publicly owned general aviation airports and establish a computerized pavement management system (PMS). The study will include the collection of pavement history, the evaluation of current pavement condition, and the establishment of a pavement maintenance schedule with estimated costs for each airport.

The PMS data will provide the means to help each individual airport economically prolong the life of their airport pavements. It also offers the GDOT the necessary information to forecast and budget statewide needs, prioritize projects, and help our state protect its multi-billion dollar investment in our statewide system of public airports.

January 1999 is the targeted completion date for the study. At the conclusion, each airport will receive an individual report containing a summary of their pavement conditions and recommendations for timely maintenance and rehabilitation (M&R). In addition, each airport will receive an electronic file containing their airport pavement database for future use.

The GDOT has awarded a contract to the engineering firm of Applied Pavement Technology, Inc. (APTech), assisted by Mayes, Sudderth & Etheredge, Inc. (MS&E), to conduct the statewide airport pavement management study.

Why is the GDOT doing this project? The state wants to protect its airport system investment. It is human nature to pay more attention to building new pavements than maintaining existing ones. However, as Georgia's airport pavement system ages, the upkeep of the existing pavements becomes increasingly important.

To determine how much money is needed and where that money would best be spent, the current condition of the airports must first be determined. This information can then be used to determine pavement M&R needs throughout the statewide airport system and analyze the consequences of various funding levels and maintenance practices.

An engineer from Applied Pavement Technology records data during a pavement evaluation survey

How will the information be used? The system will be used to develop annual pavement maintenance plans and prepare long-term pavement capital improvement programs. The system establishes a timeframe when pavement M&R should take place. This is key for improving budgeting and funds allocation. The information also allows GDOT and local airport sponsors to identify shortfalls between funding levels and M&R needs.

Have other states done this? Yes. More than half of the country's state aviation agencies have implemented pavement management systems.

Have the results been positive? Definitely. One state agency has had their system in place eight years and has been able to significantly increase the overall condition of its pavement network without a funding increase. They did this through improved prioritization and more cost-effective funding allocation.

When will the survey crews be coming to my airport? A tentative schedule has been developed, but is subject to change with springtime weather in Georgia being compounded by the infamous El Niño. Each airport owner will be contacted the week before their scheduled visit, and the day before the survey crew will call ahead to confirm their arrival.

How will our flight operations be affected? There should be no interruption to flight operations during the visual survey. The survey engineers have worked on large and small airports and understand their work is secondary to the daily operation of each airport. Handheld equipment is used during the visual survey allowing the crews to operate on a give-way basis, maintain radio communications, and yield to all aircraft operations.

What can I do to help? Nothing specific while the survey crew is on-site. However, you may be contacted by APTech or MS&E to obtain information on past construction projects that have occurred at your airport.

continued on page 2

APPLIED PAVEMENT TECHNOLOGY

Establishing a Feedback Loop

- A pavement management system must continue to reflect observed trends and agency practices
  - Update models over time
  - Keep database current
- Tie in pavement management information to others in the agency
  - Design
  - Maintenance

Link to Asset Management

- Expanding the management approach to include other physical assets
  - Trade-off decisions
  - Assist in calculating asset value

Benefits of Pavement Management

- More efficient use of available resources
- Ability to justify funding needs
- More accurate and accessible information on the pavement network
- Ability to track pavement performance
- Ability to show impacts on condition
- Improved communication

AASHTO Pavement Management Guide (2001)

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