Pavement Performance Monitoring for Asset Management

JOHN EMERY, Ph.D., P.Eng.

- John Emery Geotechnical Engineering Limited (JEGEL Group)
  Toronto, Calgary, Golden, Vancouver, Zhengzhou, and Bogotá
- Working Group Leader, WGE – Advanced Road Works Acceptance, of PIARC TC 4.2 Vehicle/Road Interaction
- Directory, Canadian National Committee of the World Road Association
- jemery@jegel.com

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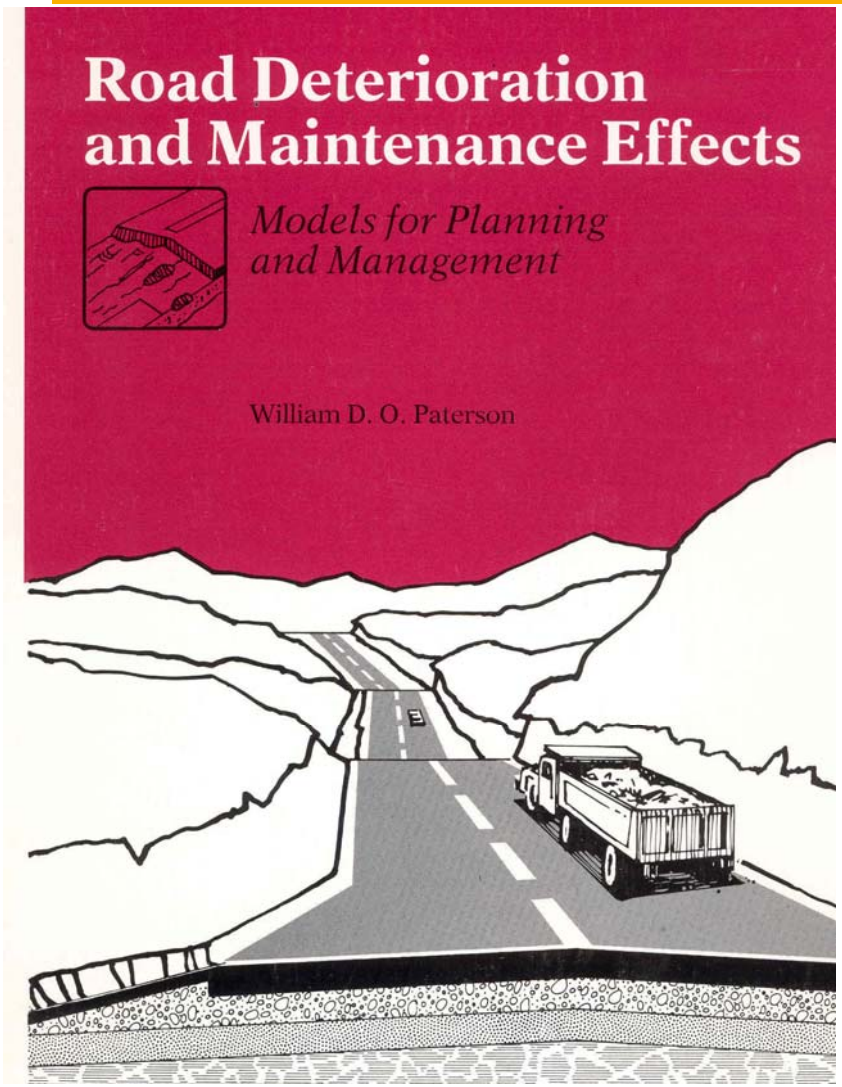
A well maintained transportation network is a valuable asset in which we all share ownership

TRB, Iowa, 1920-1995, 75 Years of Excellence…

"While automation prospers, our roads, bridges, and urban civil works rot. Children control computers while adults weave between potholes. The higher that high technology sails the worse seem our earthbound services for water, transportation, and shelter. Yet civilization is civil works and insofar as these deteriorate so does society, our high technology notwithstanding." David P. Billington, The Tower and the Bridge, 1983.

Performance Monitoring is a Key Component of Maintenance Management, Pavement Management and Transportation Asset Management Systems



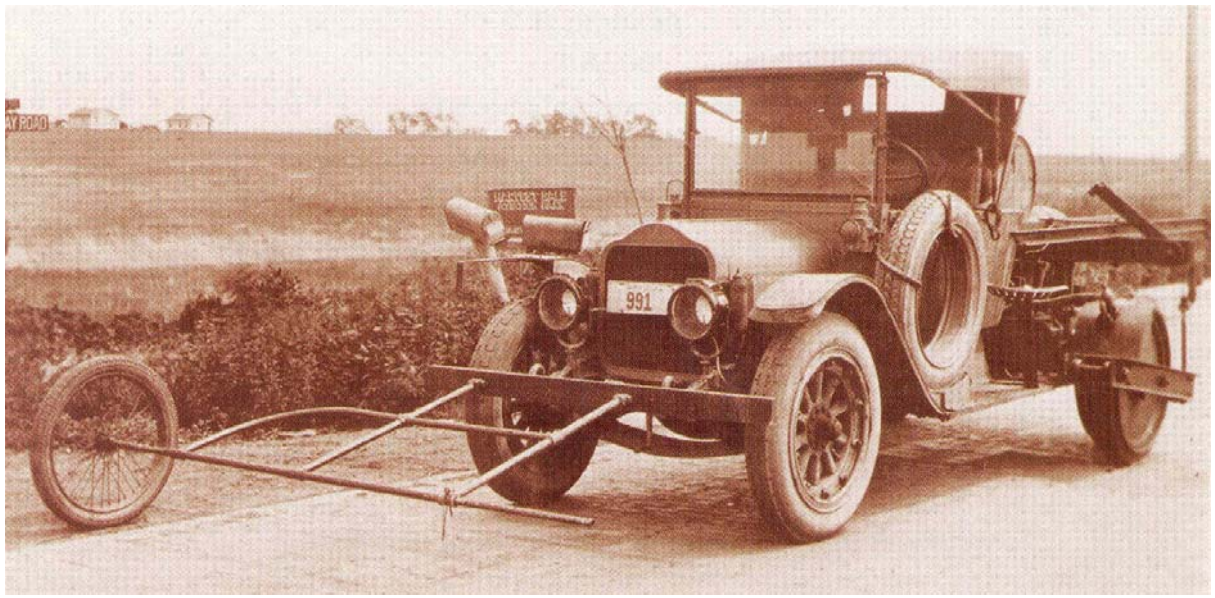
World Bank, HDM,1987

FOREWORD

An effective road transportation network is an important factor in economic and social development. It is also costly. Road construction and maintenance consume a large proportion of the national budget, while the costs borne by the road-using public for vehicle operation and depreciation are even greater. It is therefore vitally important that policies be pursued which, within financial and other constraints, minimize total transportation costs for the individual road links and for the road network as a whole. To do this meaningfully, particularly when dealing with large and diverse road networks, alternatives must be compared and the trade-offs between them carefully assessed. This in turn requires the ability to quantify and predict performance and cost functions for the desired period of analysis.

William D.O. Paterson

It is Important that the Surface Characteristics Monitoring Equipment, Quality of the Information, and its Integration Meet Recognized Standards – You Cannot Manage What You Cannot Measure



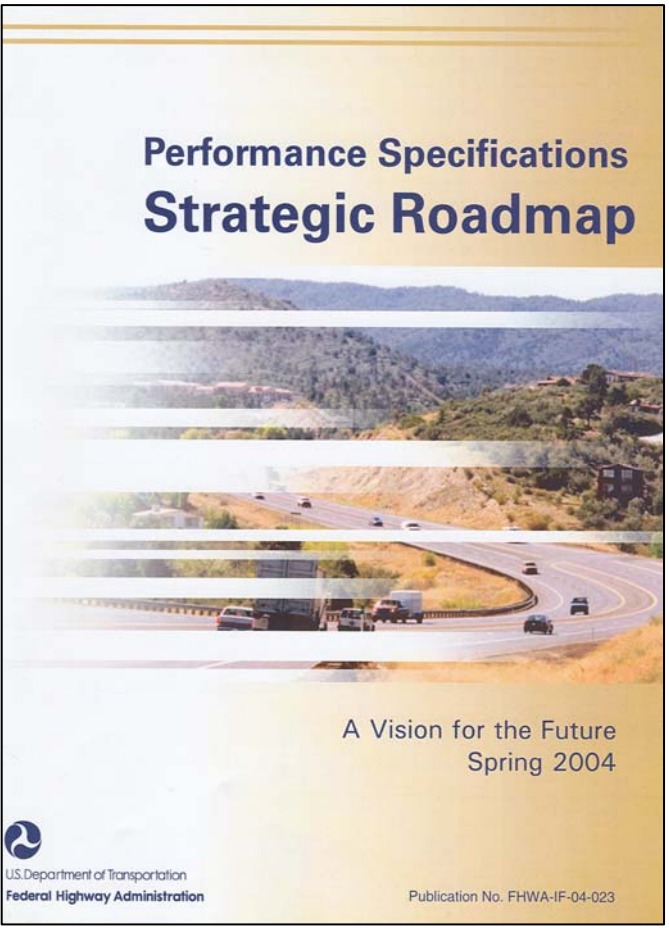
TRB, Iowa, 1920-1995, 75 Years of Excellence…

Compaction **Friction Monitoring**

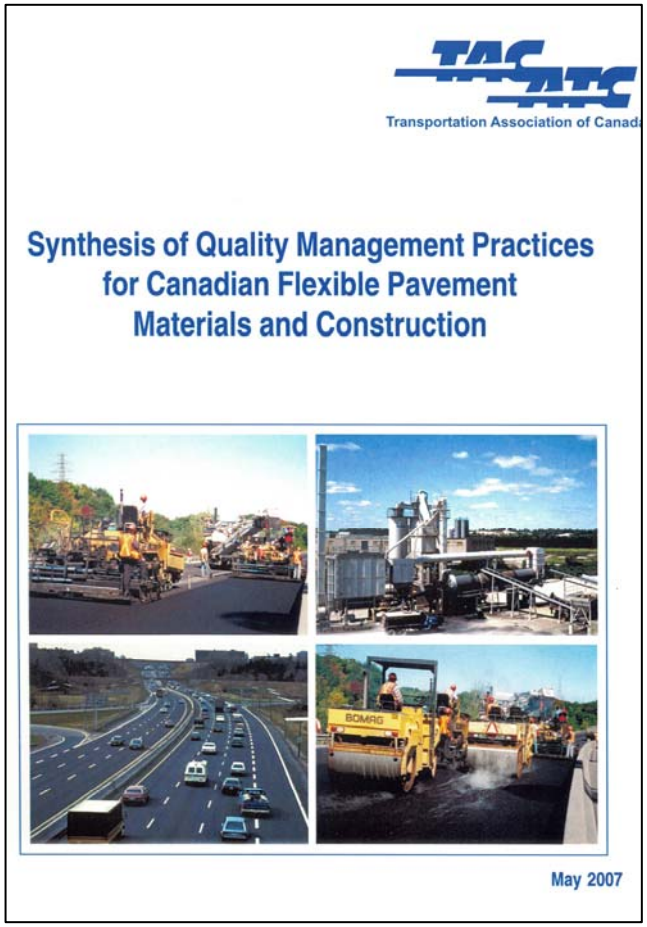
Working Group E (WGE) Activities
Performance-related Surface Condition Parameters

- **Parameters Reviewed and Accepted**
  - smoothness (International Roughness Index, IRI)
  - irregularities (bumps)
  - rutting (may be part of surface distresses)
  - surface condition (distresses – cracking, texture, segregation, ravelling/fretting, flushing, other agency specific – typically as a pavement condition index, PCI)
  - permeability
  - friction (typically benchmark then selective)
  - noise (particularly urban areas)
  - deflection (structural condition)
  - others (reflectance, for instance)
- **Ability to Incorporate New Surface Condition Features**
- **Short Term (construction and rehabilitation contracts)**
- **Longer Term (warranty, performance-related, and maintenance contracts**
- **Design-Build-Operate and Public-Private-Partnering Contracts**
- **Transportation Asset Management Systems and Components**
- **Current, Future, Low and High Technology**

Performance Specifications and Acceptance Criteria



FHWA, 2004

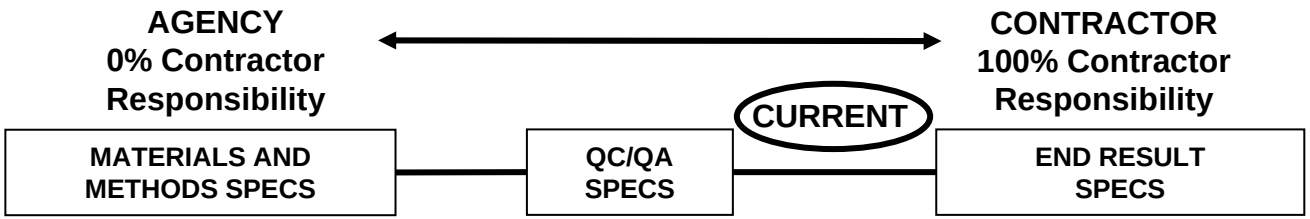


JEGEL FOR TAC, 2007

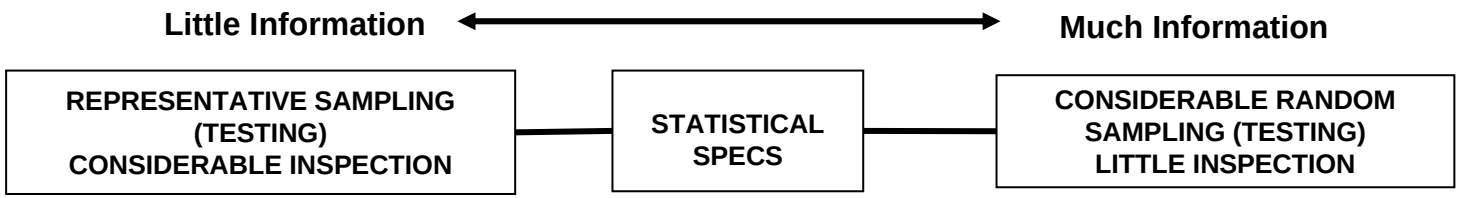
PIARC C7/8, 2003

Classifying Highway Construction Specifications

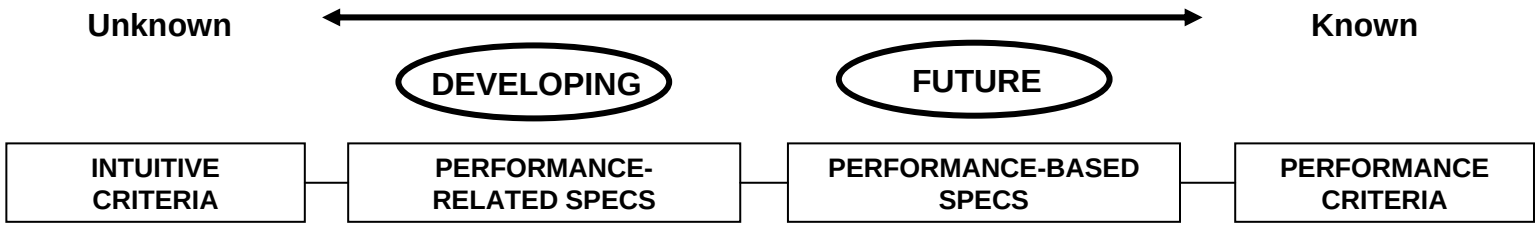
I. WHO IS RESPONSIBLE FOR THE QUALITY OF MATERIALS AND CONSTRUCTION?



II. WHAT LEVEL (TYPES) OF SAMPLING (TESTING) AND INSPECTION ARE REQUIRED?



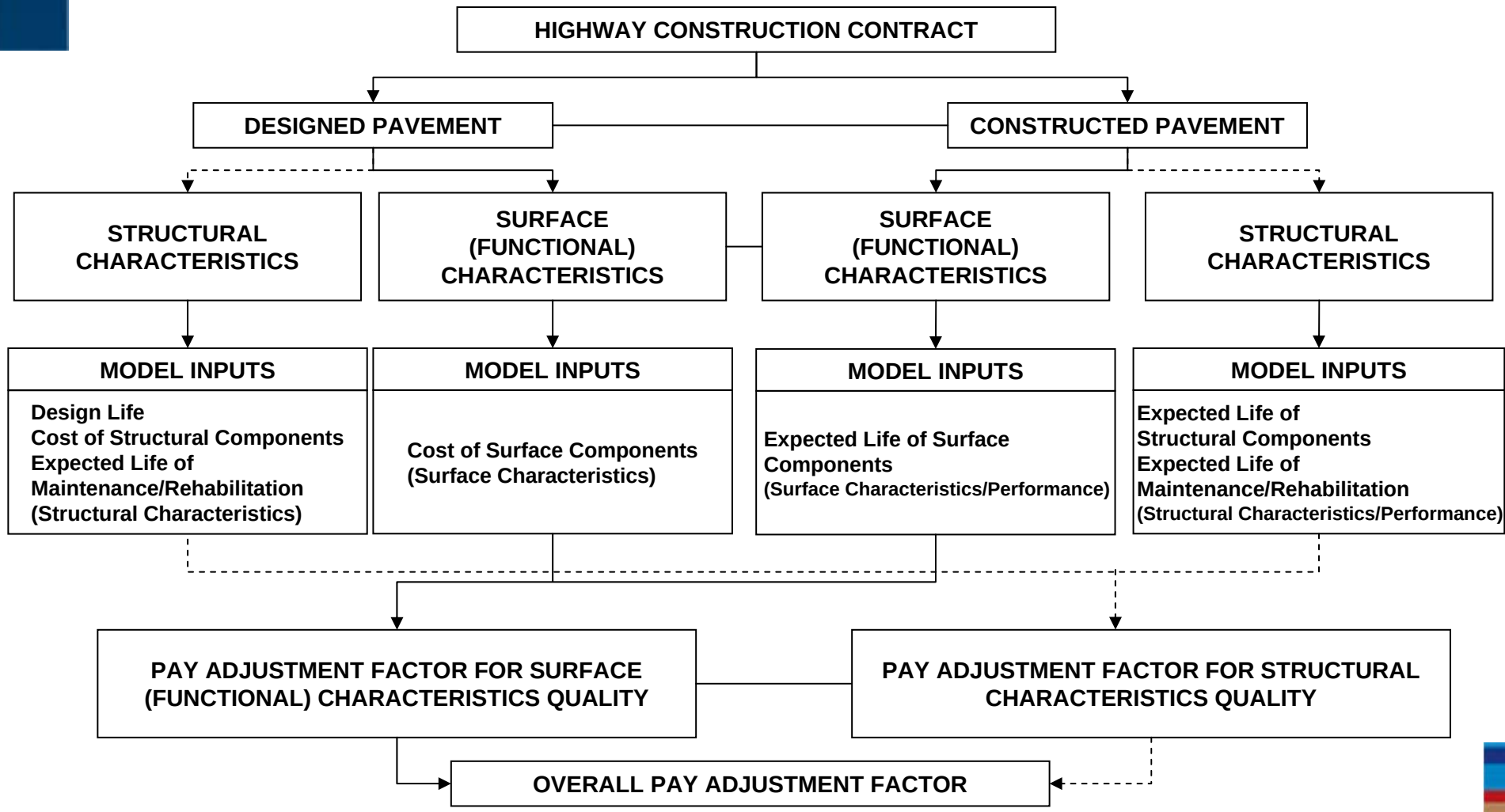
III. WHAT IS THE RELATIONSHIP(S) TO PERFORMANCE?



CLASSIFYING HIGHWAY CONSTRUCTION SPECIFICATIONS ACCORDING TO: WHO IS RESPONSIBLE FOR THE QUALITY OF MATERIALS AND CONSTRUCTION; THE LEVELS (TYPES) OF SAMPLING (TESTING) AND INSPECTION REQUIRED; AND THE RELATIONSHIP(S) BETWEEN QUALITY CRITERIA AND CONSTRUCTED FACILITY PERFORMANCE (ADAPTED FROM TRB, 2005).

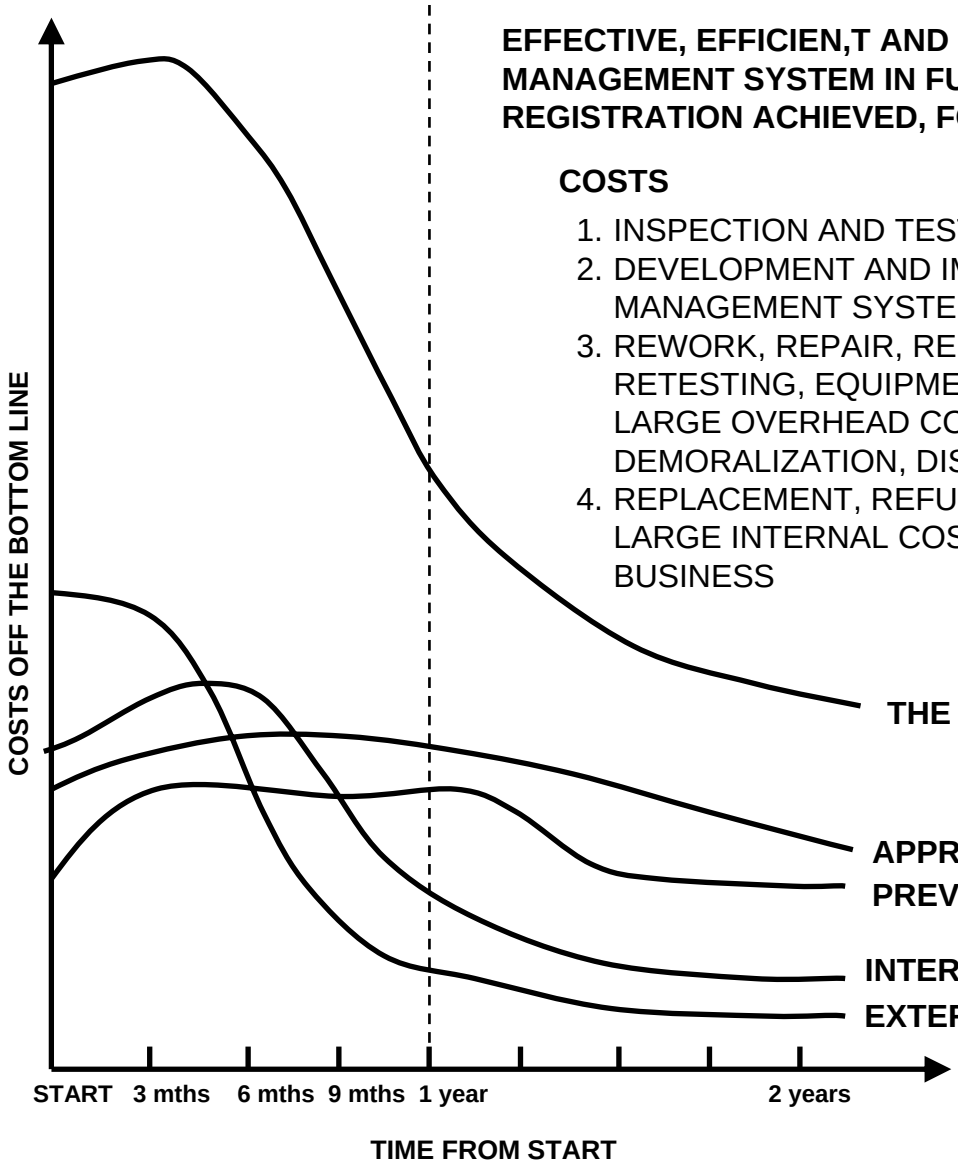
TAC, 2007

Pavement Acceptance Model Based on Structural and Surface (Functional) Characteristics



ADAPTED FROM PRACTICO, 2007

The Costs of Quality and Potential Savings - ISO



EFFECTIVE, EFFICIEN,T AND ECONOMICAL QUALITY MANAGEMENT SYSTEM IN FULL USE (ISO 9002 REGISTRATION ACHIEVED, FOR INSTANCE)

COSTS

1. INSPECTION AND TESTING
2. DEVELOPMENT AND IMPLEMENTATION OF THE QUALITY MANAGEMENT SYSTEM
3. REWORK, REPAIR, REPLACEMENT, REINSPECTION, RETESTING, EQUIPMENT DAMAGE, STAFF INJURIES, AND LARGE OVERHEAD COSTS, WITH FRUSTRATION, DEMORALIZATION, DISRUPTION, AND LATE DELIVERIES
4. REPLACEMENT, REFUNDING, WARRANTY SUPPORT AND LARGE INTERNAL COSTS, INCLUDING LOSS OF FUTURE BUSINESS

THE TOTAL COST OF QUALITY

COSTS

APPRAISAL COSTS (1)

PREVENTION COSTS (2)

INTERNAL FAILURE COSTS (3)

EXTERNAL FAILURE COSTS (4)

Adapted from Dobb, 1996

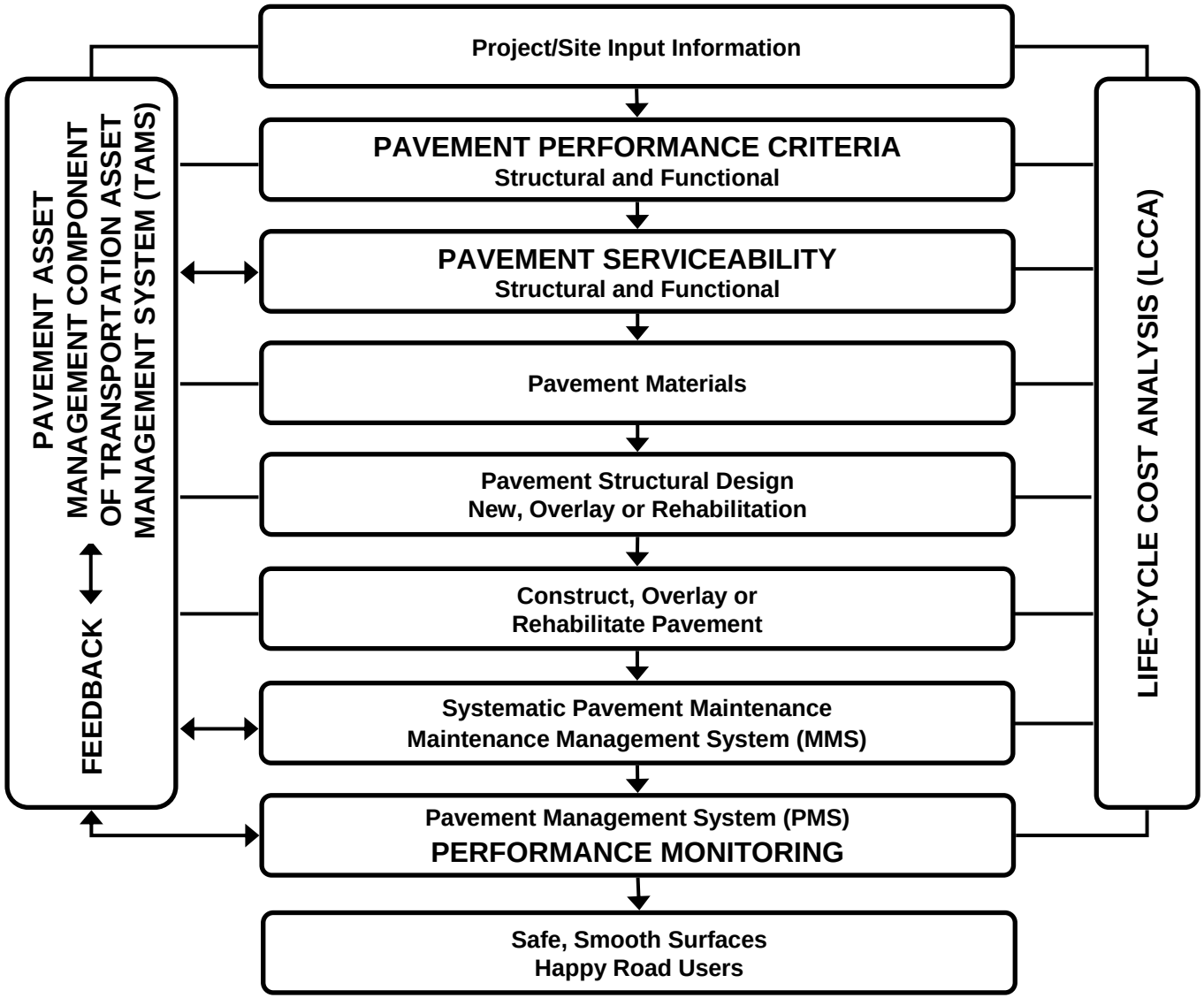
TAC, 2007

Contents of a Typical Generic Quality Management System (QMS) Compatible with ISO 9002

QMS CONTENT
Introduction Scope Normative References Terms and Definitions Quality Management System Requirements Management Responsibility Resource Management Product and/or Service Realization Measurement, Analysis and Improvement
APPENDICES FOR SPECIFIC SITE AND/OR PROJECT DESIGN, DEVELOPMENT, PRODUCTION, INSTALLATION AND SERVICES
Contract Requirements Organization Chart System Level Procedures Quality Procedures Quality Plans Work Instructions

TAC, 2007

Flexible Pavement Life

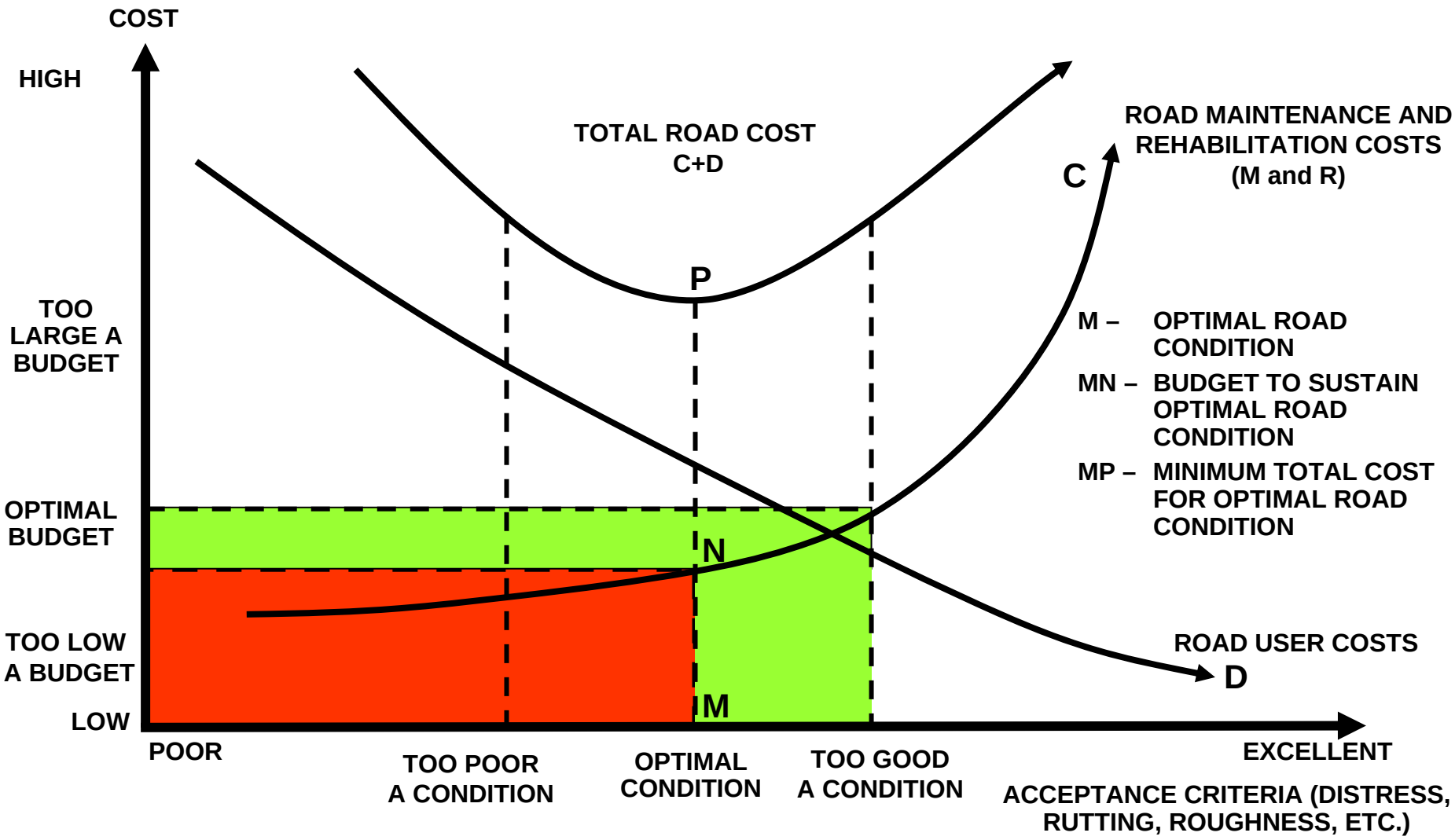


RIGID PAVEMENT LIFE SIMILAR

ADAPTED FROM TAC, 2007

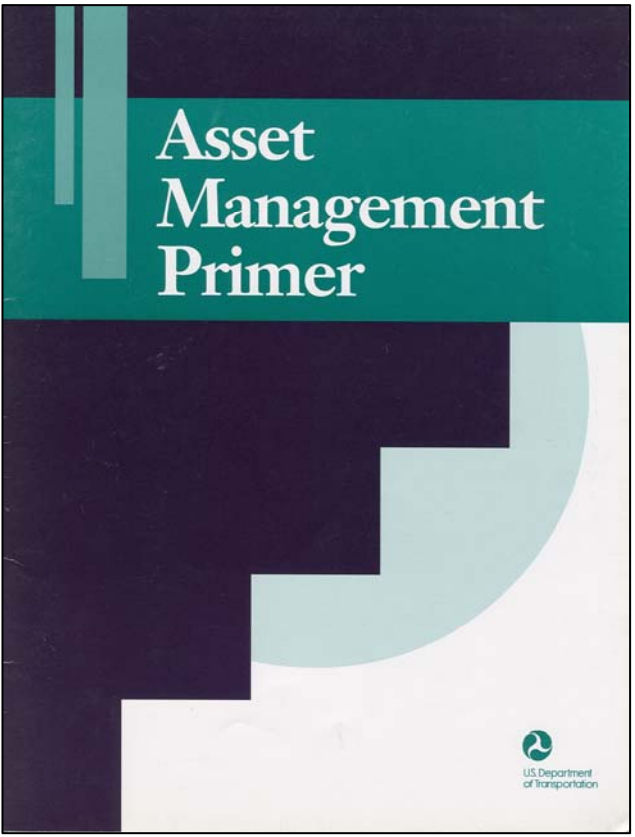
Optimizing the Total Road Cost

Investing in Roads at the Best Time with the Best Method and Best Cost / Benefit Ratio

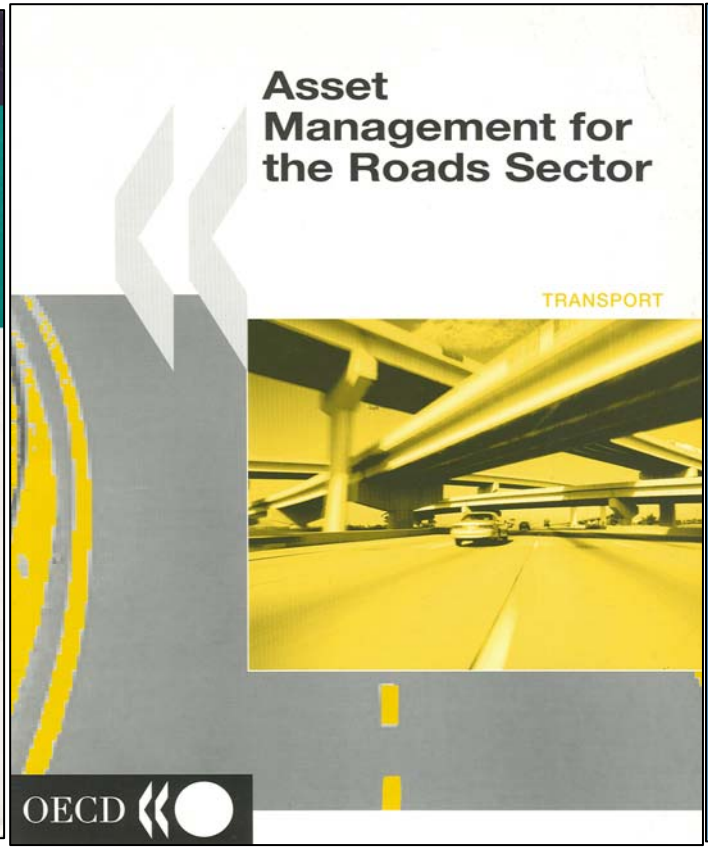


ADAPTED FROM PIARC C6, 2000

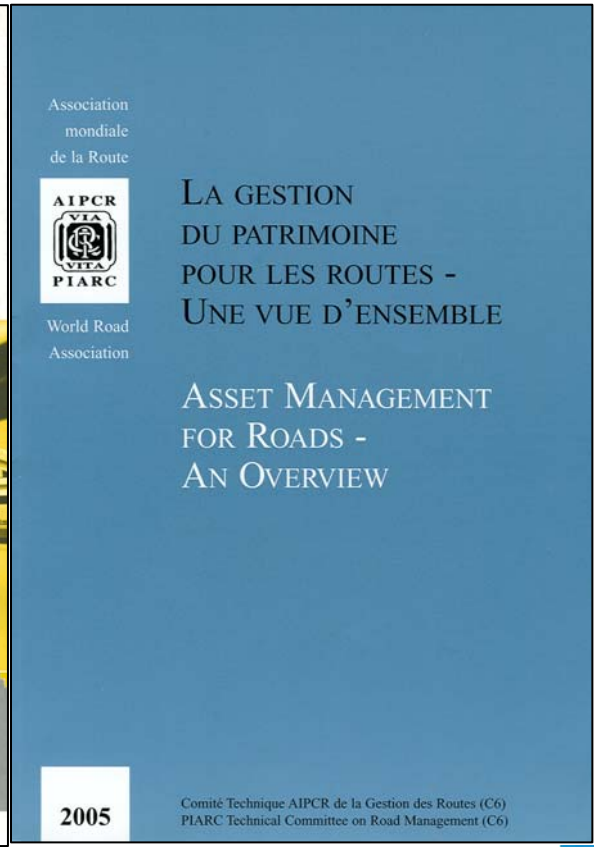
Asset Management References



FHWA, 1999



OECD, 2001



PIARC C6, 2005

Transportation Asset Management

Transportation Asset Management is a Strategic Approach to Managing Transportation Infrastructure. It Builds on Several Principles:

- **Asset Management is Policy-driven**
- **Asset Management is Performance-based**
- **Asset Management Examines Options and Trade-offs at Each Level of Decision Making**
- **Asset Management Takes the Long-term View**
- **Asset Management Bases Decisions on Merit**
- **Asset Management Provides Clear Accountability**

Cactus, Villa Paula Quarry, Bogotá, Colombia

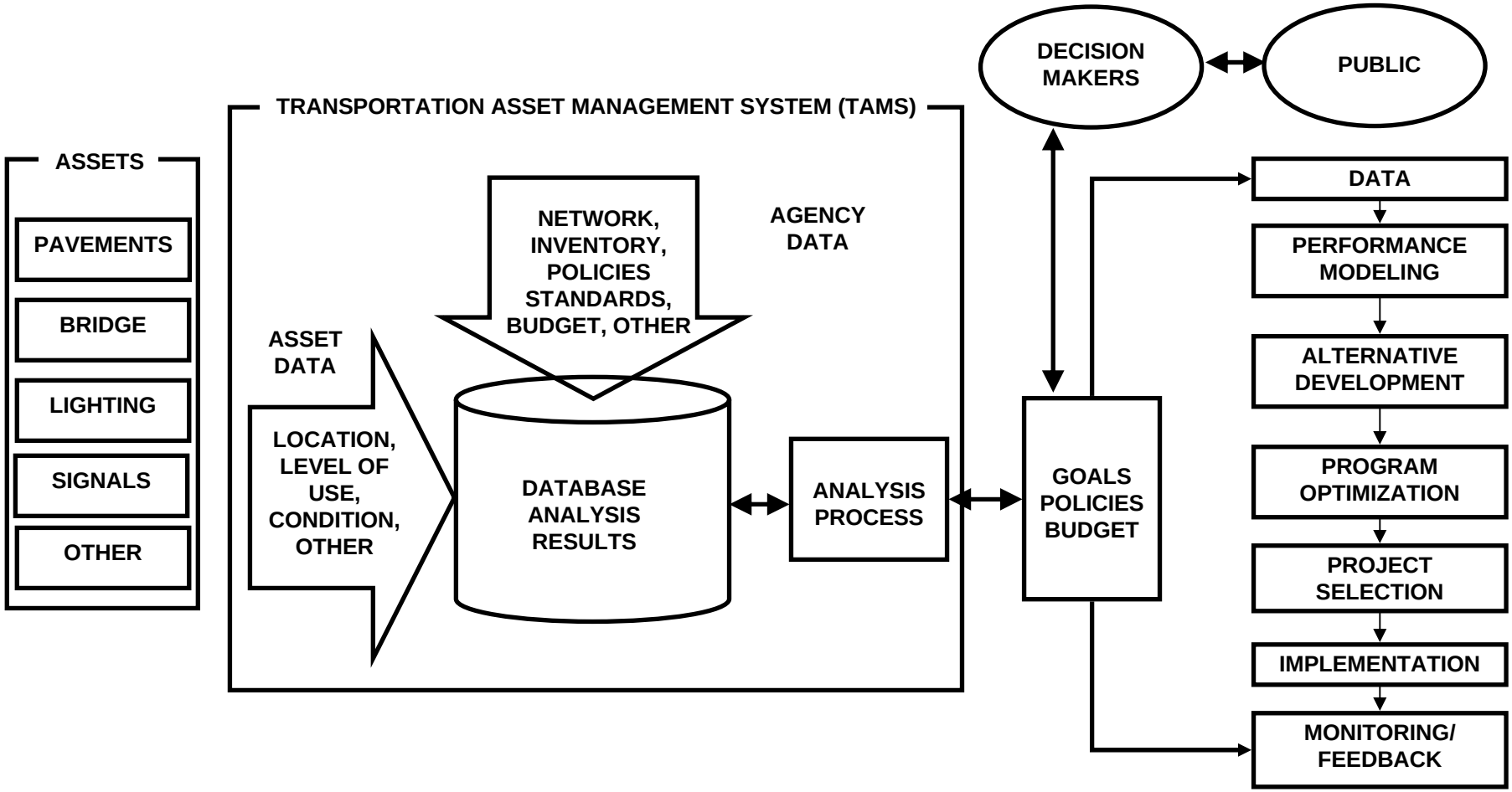
TAM – Investment Categories

- ***Preservation*** **Extends the Life of an Asset or Corrects a Distress That Impedes Mobility, Safety, Serviceability, or Engineering Integrity**
- ***Operations*** **Focus on Real-time Service and Operating Efficiency**
- ***Capacity Expansion*** **Affects a Facility's Level of Service by Adding Physical Capacity, by Creating New Capacity Through a New Facility, or by Implementing Long-term Operating Strategies**

Flamboyan Tree near Santiago, Dominican Republic

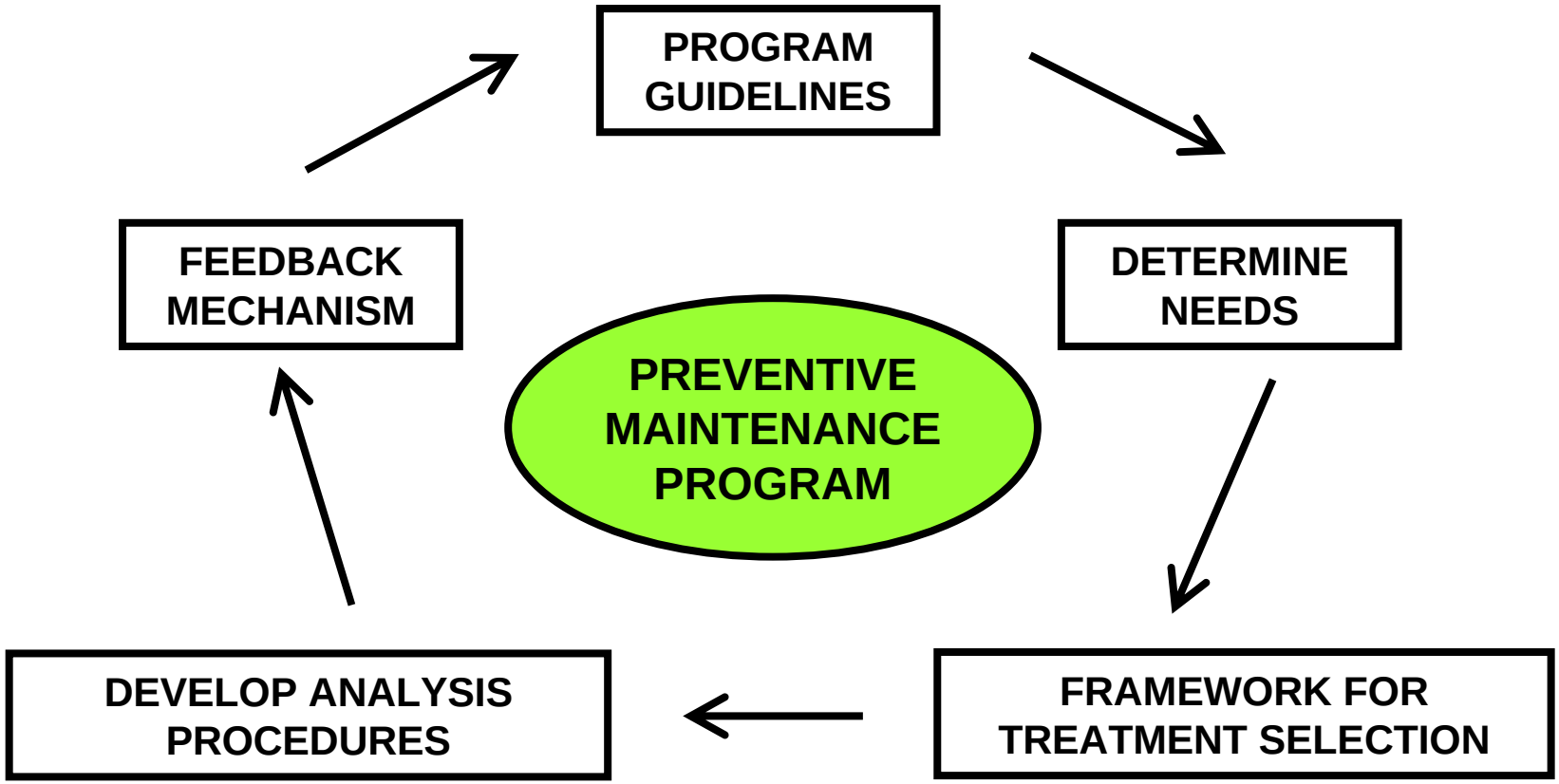
Transportation Asset Management System (TAMS)

Typical Flow of Asset and Agency Data in and Out of a Generic Transportation Asset Management System



ADAPTED FROM OECD, 2001

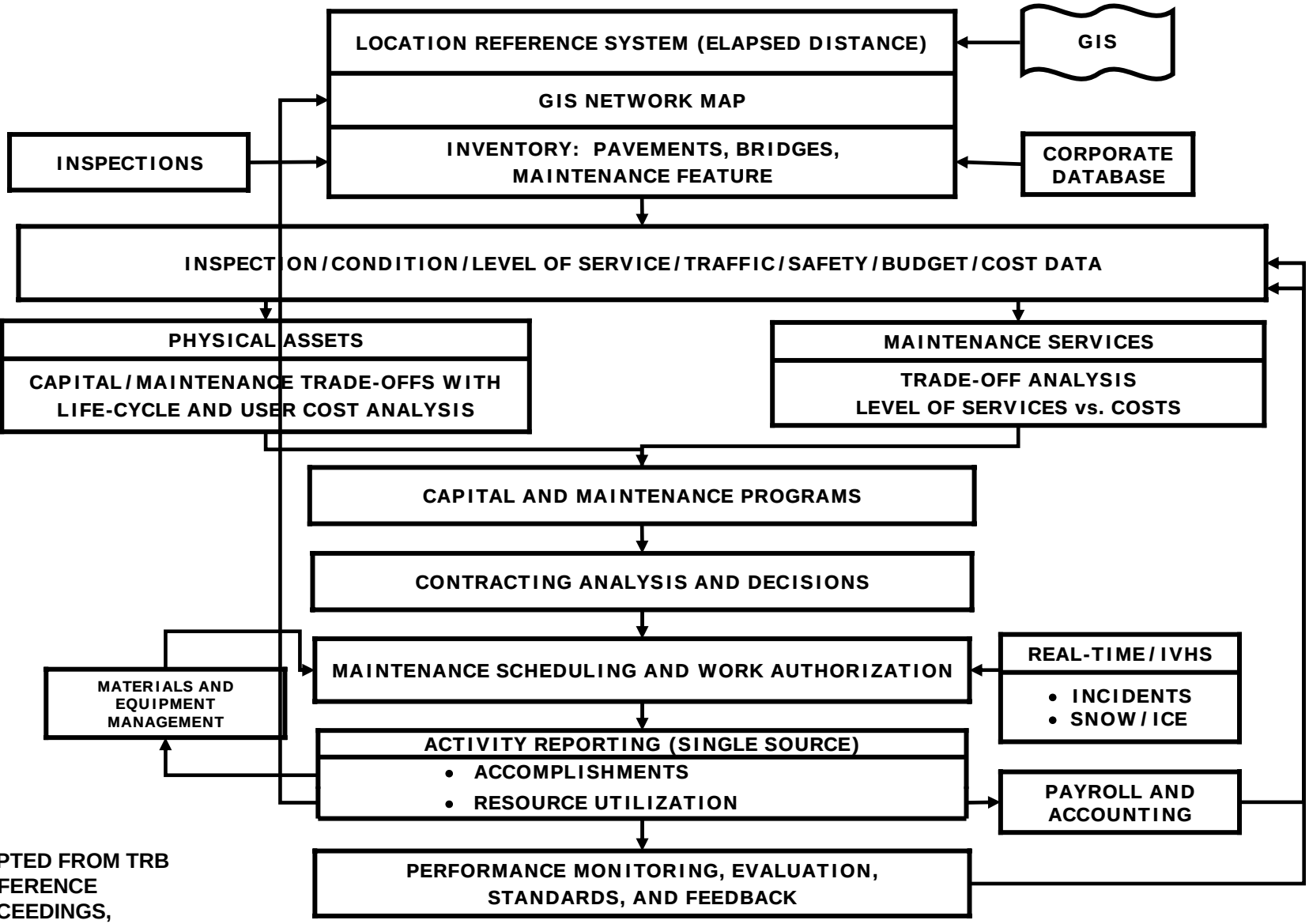
Establishing a Preventive Maintenance Program



MMS ⟷ PMS ⟷ AMS

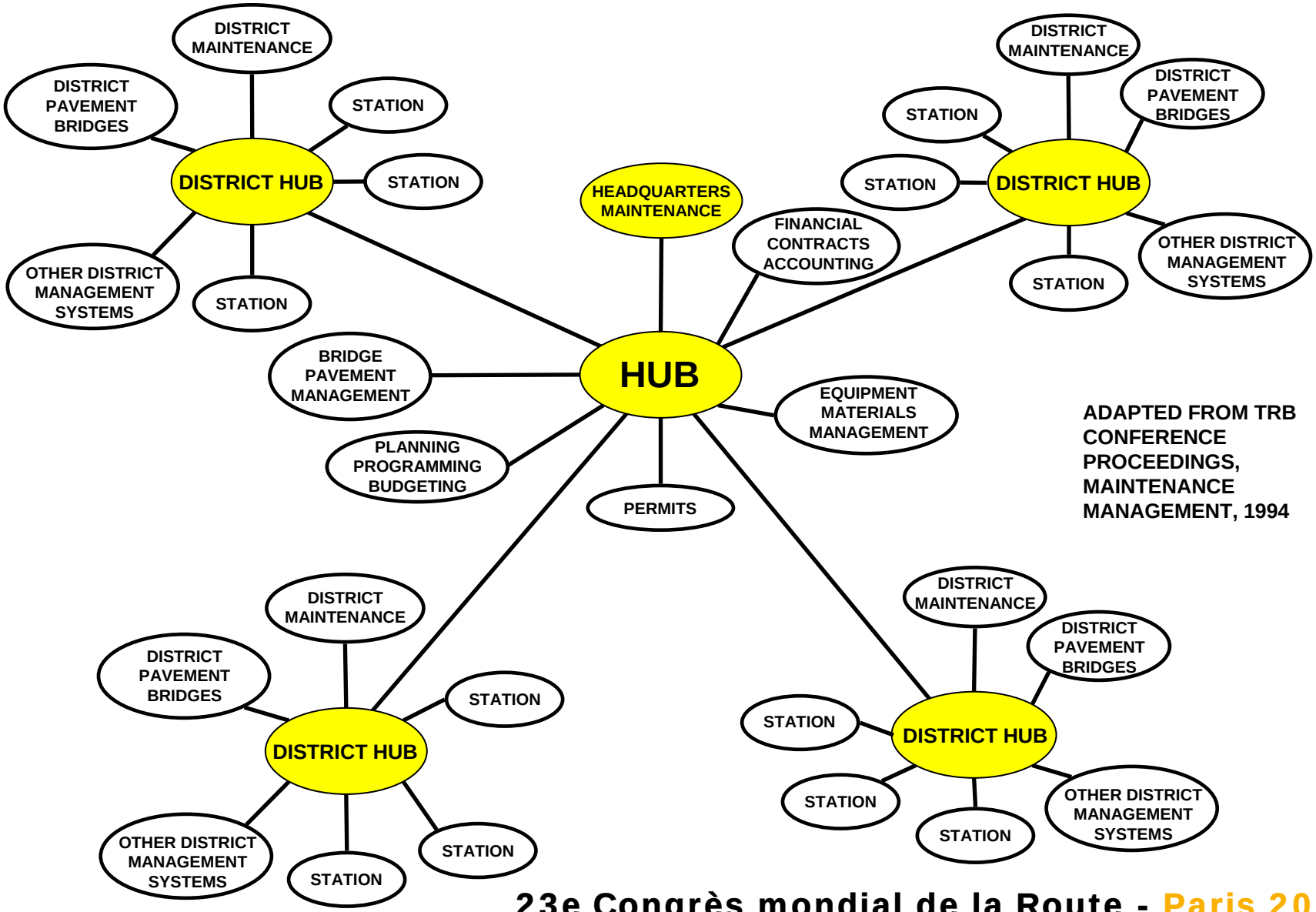
ADAPTED FROM FP[2]

Example of an Integrated Maintenance Management System (MMS) Approach



ADAPTED FROM TRB CONFERENCE PROCEEDINGS, MAINTENANCE MANAGEMENT, 1994

Application of MMS Hub-and-Spoke and Systems Integration Concepts Within an Organization



ADAPTED FROM TRB CONFERENCE PROCEEDINGS, MAINTENANCE MANAGEMENT, 1994

Four Steps In The Implementation Timeline For An Infrastructure Component Of A Tams

1. **Develop the Framework (Functional Design)**
   - Identify Decision Makers, System Objectives, Required Data And Sources Of Data
   - Review Current Management Processes, If Any
   - Define Enhanced Or New Management Processes (Generally Follow Government Accounting Standards Board (GASB) 34 Guidelines
   - Determine Implementation Timing
2. **Put the System Together**
   - Evaluate Available Software And Select/Develop For Functional Designs
   - Select Hardware
   - Establish Support Services Such As Information Technology, Training And Implementation, And Data Collection And Conversion
   - Initiate Supporting Services Including Beta Testing
3. **Complete Initial Inventory (Database)**
   - Review System Objectives
   - Implement System (Hardware, Software And Training)
   - Complete Pilot Inventory (Database) And System Use
   - Evaluate System (Corrective Actions As Necessary)
   - Begin Inventory (Database)
   - Begin Using The System And Enforce Procedures
   - Schedule Data Update And Routine Data Checks
   - Maintain The System
4. **Plan for the Future**
   - Review System Objectives
   - Evaluate Overall System And Budget For Expansion, Enhancement And New Technology
   - Implement Improvements

Surface Condition Indices
Example – Engineering Rating of Airport Pavements
US Air Force

US AIR FORCE ETL 99-7

PAVEMENT CONDITION ASSESSMENT STANDARDS

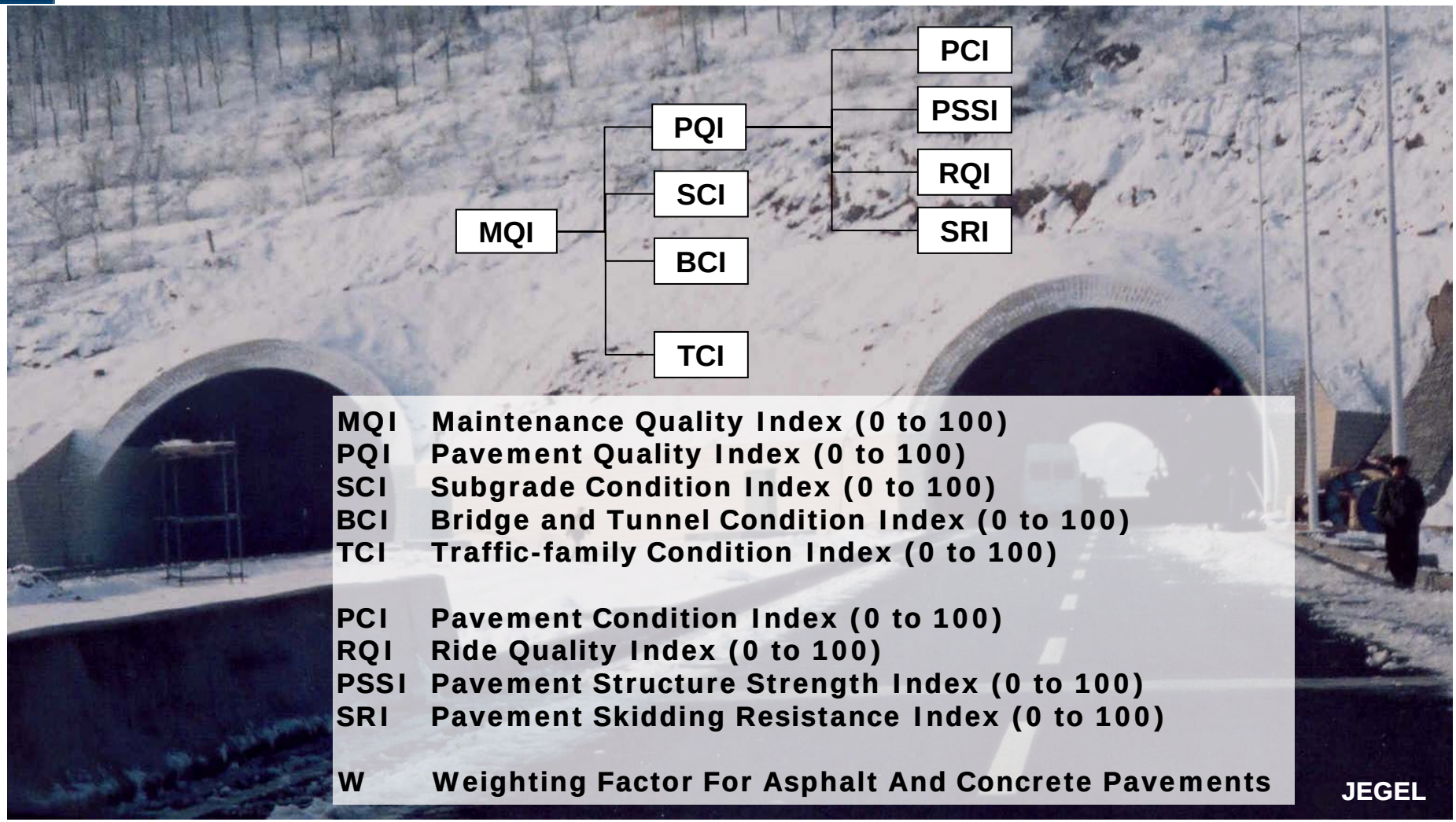
PAVEMENT CONDITION INDEX (PCI)

- ASTM D 5340, Test Method For Airport Pavement Condition Index Surveys
- MicroPAVER (American Public Works Association) Friction Index
- Federal Aviation Authority (FAA) Advisory Circular 150/5320-12, Measurement, Construction, and Maintenance of Skid-resistant Airport Pavement Surfaces Structural Index
- International Civil Aviation Organization (ICAO) Foreign Object Damage (FOD) Index
- MicroPAVER (FOD Related Distresses)

CORRELATION AND RATING FOR FRICTION EQUIPMENT

EQUIPMENT / FRICTION RATING	NOMINAL TEST SPEED, 65 km/h (40 mph) GROUND VEHICLE READINGS								INTERNATIONAL CIVIL AVIATION ORGANIZATION ICAO INDEX
	GRIP-TESTER	JAMES BRAKE INDEX	MU-METER	SURFACE FRICTION TESTER	RUNWAY FRICTION TESTER	BV-11 SKIDDO-METER	DECEL METERS	LOCKED WHEEL DEVICES	
ADEQUATE	> 0.49	> 0.58	> 0.50	> 0.54	> 0.51	> 0.59	> 0.53	> 0.51	5
MARGINAL	0.34-0.49	0.40-0.58	0.35-0.50	0.38-0.54	0.35-0.51	0.42-0.59	0.37-0.53	0.37-0.51	3-4
UNSATISFACTORY	≤ 0.33	≤ 0.39	≤ 0.34	≤ 0.37	≤ 0.34	≤ 0.41	≤ 0.36	≤ 0.36	1-2

Surface Condition Indices
Use of Derived Indices for Pavement Condition
Example – Expressway Maintenance Quality Evaluation Standards



MQI	Maintenance Quality Index (0 to 100)
PQI	Pavement Quality Index (0 to 100)
SCI	Subgrade Condition Index (0 to 100)
BCI	Bridge and Tunnel Condition Index (0 to 100)
TCI	Traffic-family Condition Index (0 to 100)
PCI	Pavement Condition Index (0 to 100)
RQI	Ride Quality Index (0 to 100)
PSSI	Pavement Structure Strength Index (0 to 100)
SRI	Pavement Skidding Resistance Index (0 to 100)
W	Weighting Factor For Asphalt And Concrete Pavements

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New Urumqi Ring Road, Xinjiang Uygur Autonomous Region

Example of Performance Specifications for Highway Pavement Patching and Crack Sealing British Columbia

		SUMMER HIGHWAY CLASSIFICATION				
PAVEMENT DEFICIENCY	SEVERITY	1 and 2	3	4	5	6 and 7
POTHOLE ON TRAVELLED LANE OR INNER SHOULDER OF CURVED HIGHWAY SECTIONS	HIGH	24 HOURS	2 DAYS	3 DAYS	7 DAYS	14 DAYS
POTHOLES ON OUTSIDE SHOULDER OF CURVED HIGHWAY SECTIONS AND TANGENTS	HIGH	3 DAYS	7 DAYS	10 DAYS	21 DAYS	45 DAYS
POTHOLE ON RIGHT EDGE OF DIVIDED HIGHWAY IN THE DIRECTION OF TRAVEL	HIGH	24 HOURS	2 DAYS	3 DAYS	7 DAYS	14 DAYS
POTHOLE ON LEFT EDGE OF DIVIDED HIGHWAY IN THE DIRECTION OF TRAVEL	HIGH	3 DAYS	7 DAYS	10 DAYS	21 DAYS	45 DAYS
BLEEDING ON TRAVELLED LANE, OR INSIDE SHOULDER OF CURVED HIGHWAY SECTIONS	HIGH	24 HOURS	2 DAYS	3 DAYS	7 DAYS	14 DAYS
DISTORTIONS PRESENTING A SAFETY HAZARDS	HIGH	24 HOURS	2 DAYS	3 DAYS	7 DAYS	14 DAYS

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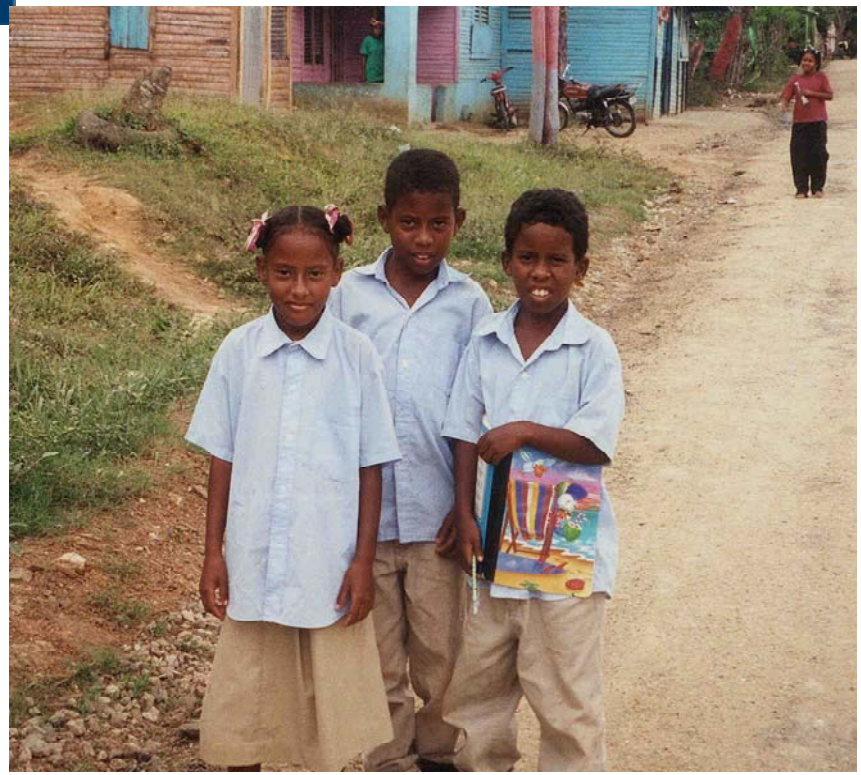
Quality Pavement for Quality Life



Completed Carretera Hato Mayor Near El Valle, Dominican Republic, 2001
Note the Harmony with the Adjacent Farms And Vegetation Including African Palms
This is a Living Highway that is Critical to Both the Physical (Transportation for Instance) and the Social Infrastructure (Schools and Hospitals, for Instance) in this Rural Area of the Dominican Republic

Questions?