Pavement Engineering and Maintenance Management

12-13, November, 2007

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Organized by

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&

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Lecture Plan

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Lecture 4	Priority Rating and Pavement Maintenance Planning
Lecture 5	Pavement Roughness Evaluation
Lecture 6	Skid Resistance Evaluation of Pavement
Lecture 7	Nondestructive Deflection Testing of Pavement
Lecture 8	Structural Evaluation of Pavements
Lecture 9	Budget Planning and Optimal Programming
Lecture 10	Concept of Highway Asset Management

Main Reference :

T. F. Fwa

“The Handbook of Highway Engineering”

published by CRC Press / Taylor & Francis Group, 2006.

Lecture 1

Concept of Total Highway Management & PMS

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2007

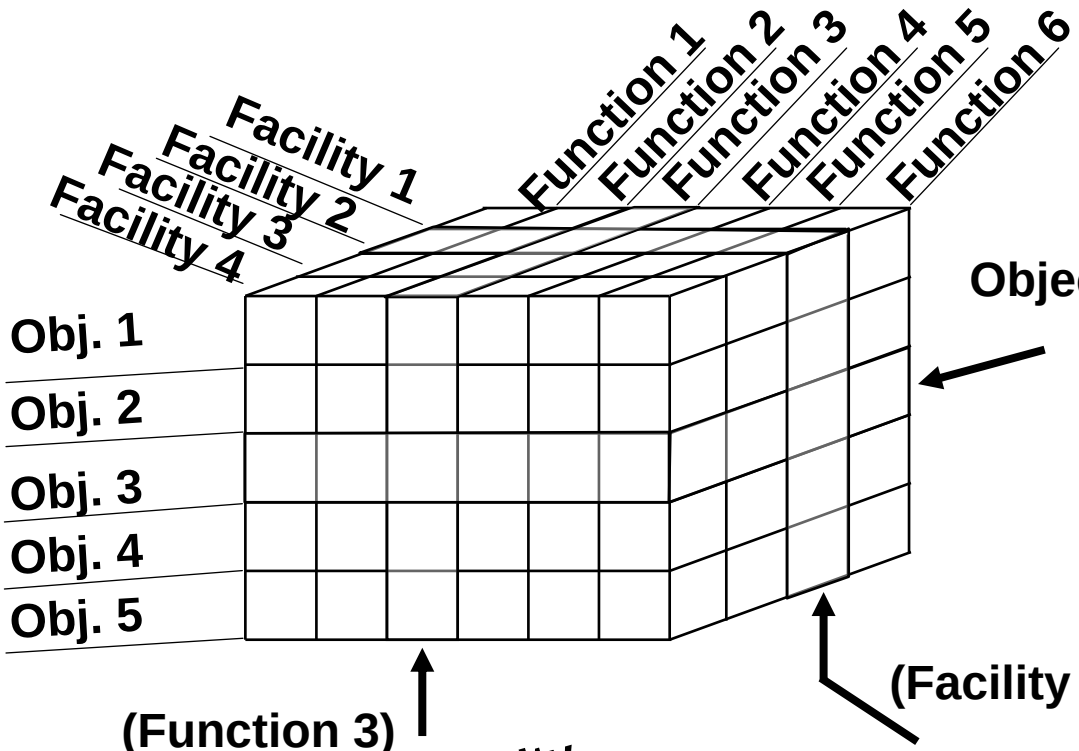
Concept of Total Highway Management

Three basic elements of a highway system:

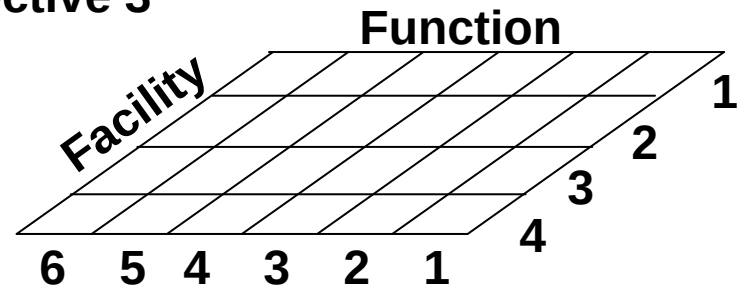
1. Highway Facility	2. Operational Function	3. System Objective
• Pavements • Bridges • Traffic control devices • Structures • Roadside appurtenances	• Planning • Design • Construction • Condition evaluation • Maintenance • Improvement/ Rehabilitation • Data management/ Information management	• Service • Condition • Safety • Cost • Socio-economic factors • Energy

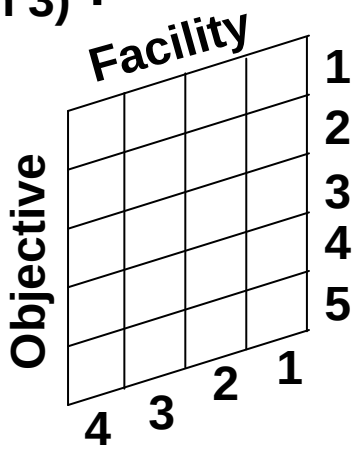
Concept of Total Highway Management

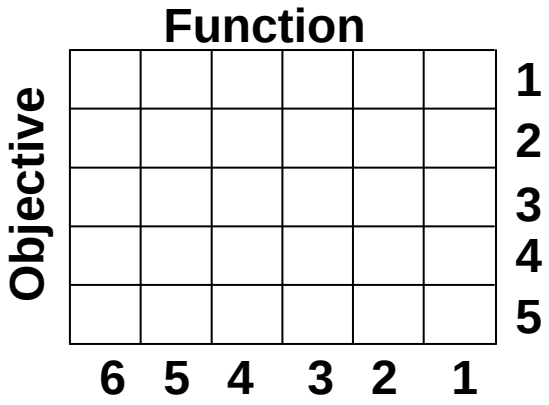
3-D Matrix Structure of Highway Management System



Objective 3







Performance Indicators for Highway System Objectives

The ultimate goal of a highway program is to satisfy the system objectives as closely as possible within the constraints of resources and other factors.

Usefulness of Performance Indicators:

1. Allow system objectives to be assessed quantitatively.
2. Provide indications of the degree of fulfilment of system objectives.
3. Priority ranking of facilities can be established based on the relative values of performance indicators.
4. Used for comparison of effectiveness or adequacy of alternative design schemes, or maintenance and improvement strategies.
5. They can be easily incorporated into a mathematical optimisation programming model.

Performance Indicators for Highway System Objectives

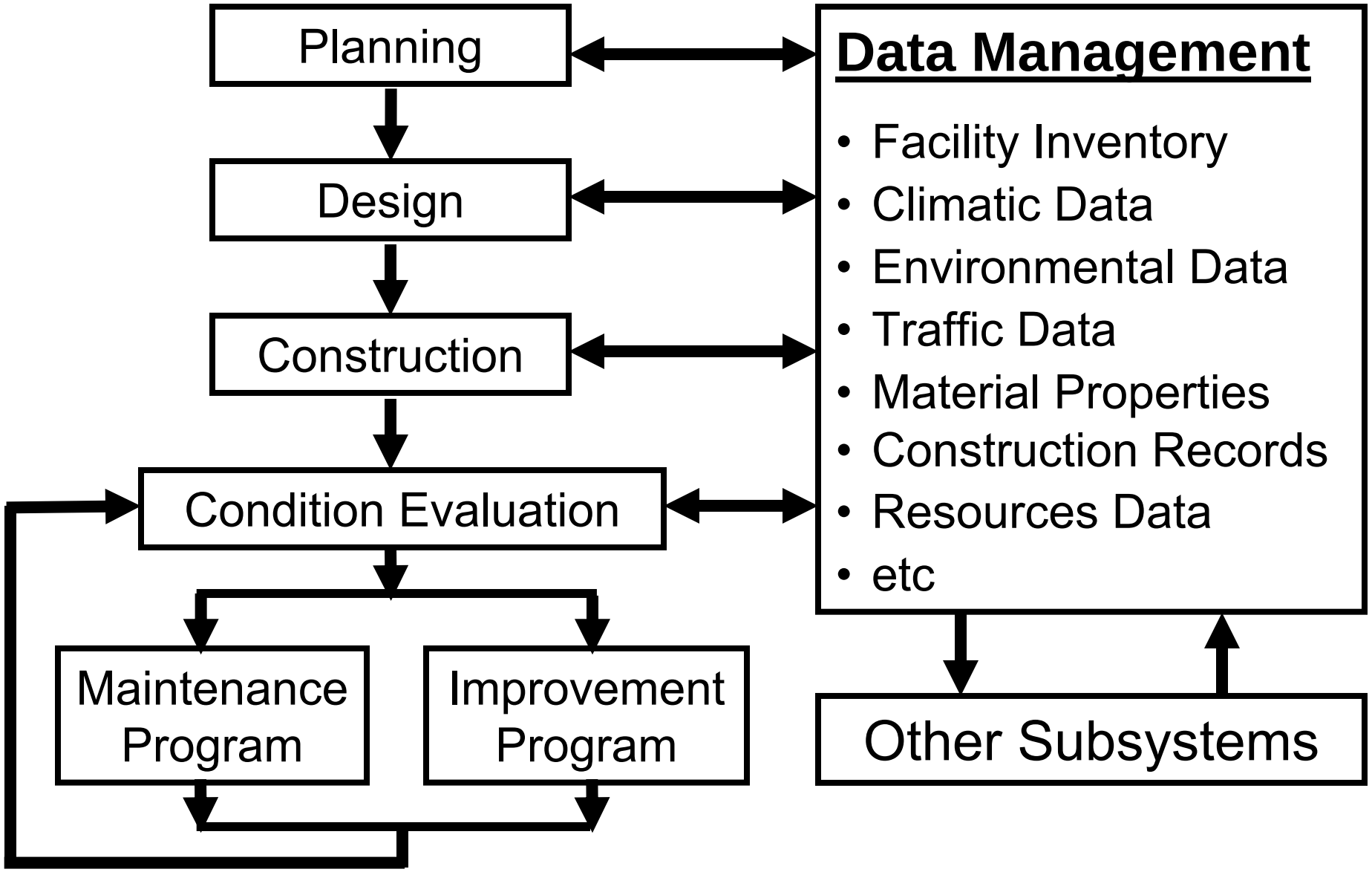
Facility \ Objective	Service	Condition	Safety
Pavements	• V/Cap ratio • Travel speed • Serviceability	• Structural cap. • Distress severity • Serviceability	• Skid resistance • Accident occurrences
Bridges	• Deck width • Vertical clearance • Traffic speed	• Load capacity • Remaining service life • Structural part deterioration index	• Load cap. • Clear deck width • Accident occurrences
Roadside Facility	• Travel speed • Clear roadway width	• Structural cap. • Remaining service life • Deterioration index	• Vehicle impact performance • Night visibility
Traffic Control Devices	• V/Cap ratio • Delay time	• Visibility • Deterioration index	• Sight distance • Luminance

Performance Indicators for Highway System Objectives

Objective / Facility	Cost	Socio-Economic Factors	Energy
Pavements	• Agency costs • User vehicle operating costs	• Noise level • Visual quality • Travel time saving • Material recycling level	• Fuel consumption
Bridges	• Agency costs • User costs	• Travel time saving • Visual quality	• Fuel consumption
Roadside Facility	• Agency costs • User costs	• Accident reduction • Visual quality • Noise reduction	• Fuel consumption
Traffic Control Devices	• Agency costs • User costs	• Travel time saving • Accident reduction • Driver satisfaction	• Fuel consumption

Concept of Total Highway Management

Activities in a Highway Facility Management System



Requirements of Highway Management Systems

Comprehensiveness	•All aspects addressed •Balanced solutions
Flexibility	•To accommodate varying demand, future development, new situations
Applicability	•System to meet the need at different management levels and localities
Sensitivity	•Responsive to impacts and changes

The primary function of a highway management system is to serve as a decision making tool for highway agencies.

Characteristics of Total Highway Management

1. Multi-element facilities, each forming a subsystem. All compete for the same pool of funds and resources.
2. Overall effectiveness of a highway system depends on the levels of services provided by the individual subsystems.
3. Resources are limited, need for optimal allocation based on relative importance.
4. Systems approach required to carry out different operational functions to achieve optimal operational effectiveness and efficiency. (e.g. Design vs. Maintenance vs. Rehabilitation)
5. Multi-objective problem
   - Maximize level-of-service
   - Maximize facility condition
   - Maximize safety
   - Minimize agency and/or user costs
   - Minimize use of environmental and energy resources
   - Maximize socio-environmental benefits

Not all objectives can be achieved simultaneously.

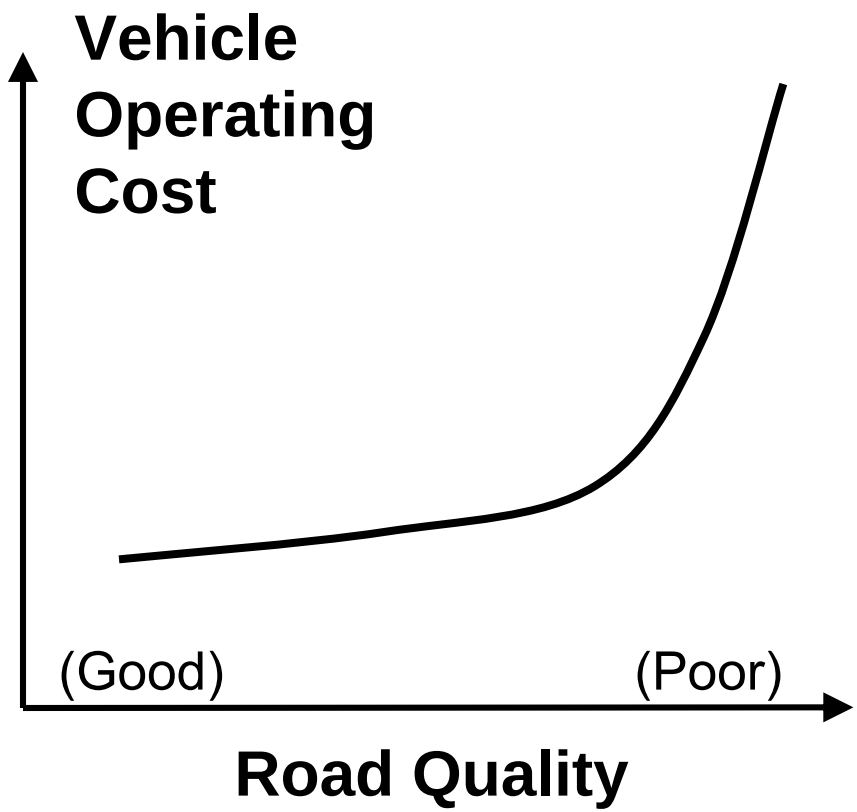
Pavement Management System (PMS)

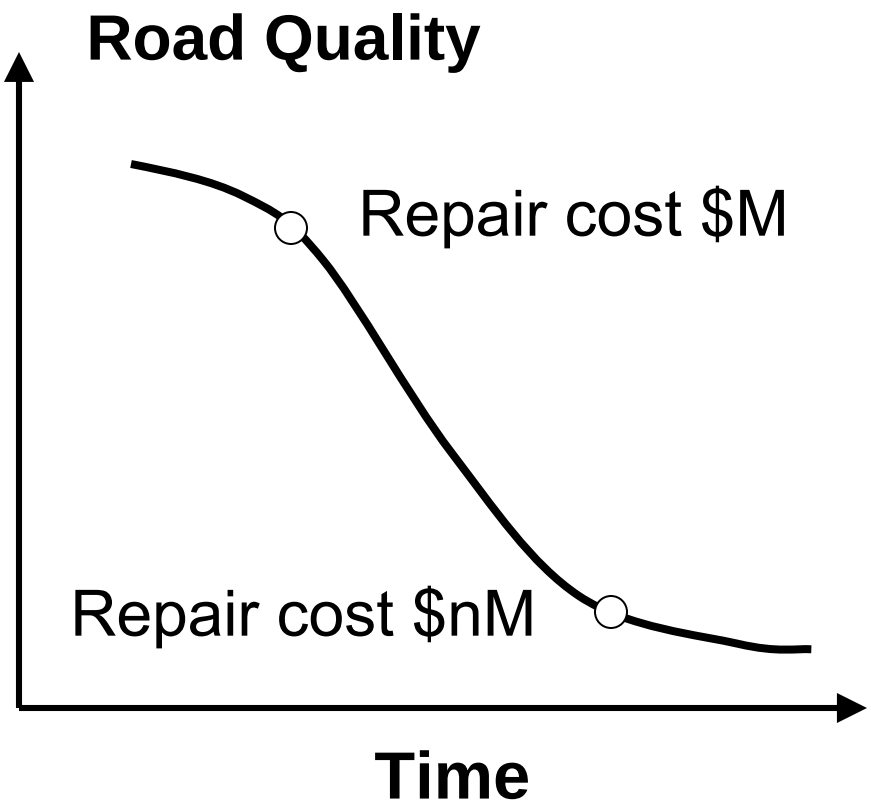
Objectives: Programming of pavement investments for a network of roads to achieve optimal results with the available funds.

Why Pavement Management ?

- Provide necessary information to decision makers
  – how much, where and when money should be spent
  – consequences of different alternatives
- Save costs to users of roads
- Save costs to owners of roads
- Funds are limited

Trend and Implication of Road Quality Variation





Definition of PMS

- A comprehensive, coordinated set of activities associated with the planning, design, construction, maintenance, evaluation and research of pavements. (Haas & Hudson 1978)
- The process of co-ordinating and controlling a comprehensive set of activities to provide and maintain pavements, so as to make the best possible use of resources available (i.e. maximize the benefit for society) (OECD 1987)
- A systems engineering approach to the problem of planning, design, construction, maintenance, rehabilitation and reconstruction of pavements in an optimal manner of resource utilization to best satisfy a desired set of objectives.

  Resources: materials manpower, equipment, time, fund
  Objectives: service, condition, safety, cost, energy, socio-economic factors

Functional Phases of a PMS

- Planning
- Design
- Construction
- Maintenance
- Rehabilitation
- Reconstruction

Planning

- Program
- Budget
- Allocation of funds
- Revenue (e.g. user tax structure)

Design

- Structural design
- Traffic capacity
- Service life
- Service quality

Construction

- Costs
- Specification
- Quality control
- Schedule

Functional Phases of a PMS *(cont'd)*

- Planning
- Design
- Construction
- Maintenance
- Rehabilitation
- Reconstruction

Maintenance

- Type of treatment
- Frequency
- Level of maintenance
- Programming
- Scheduling

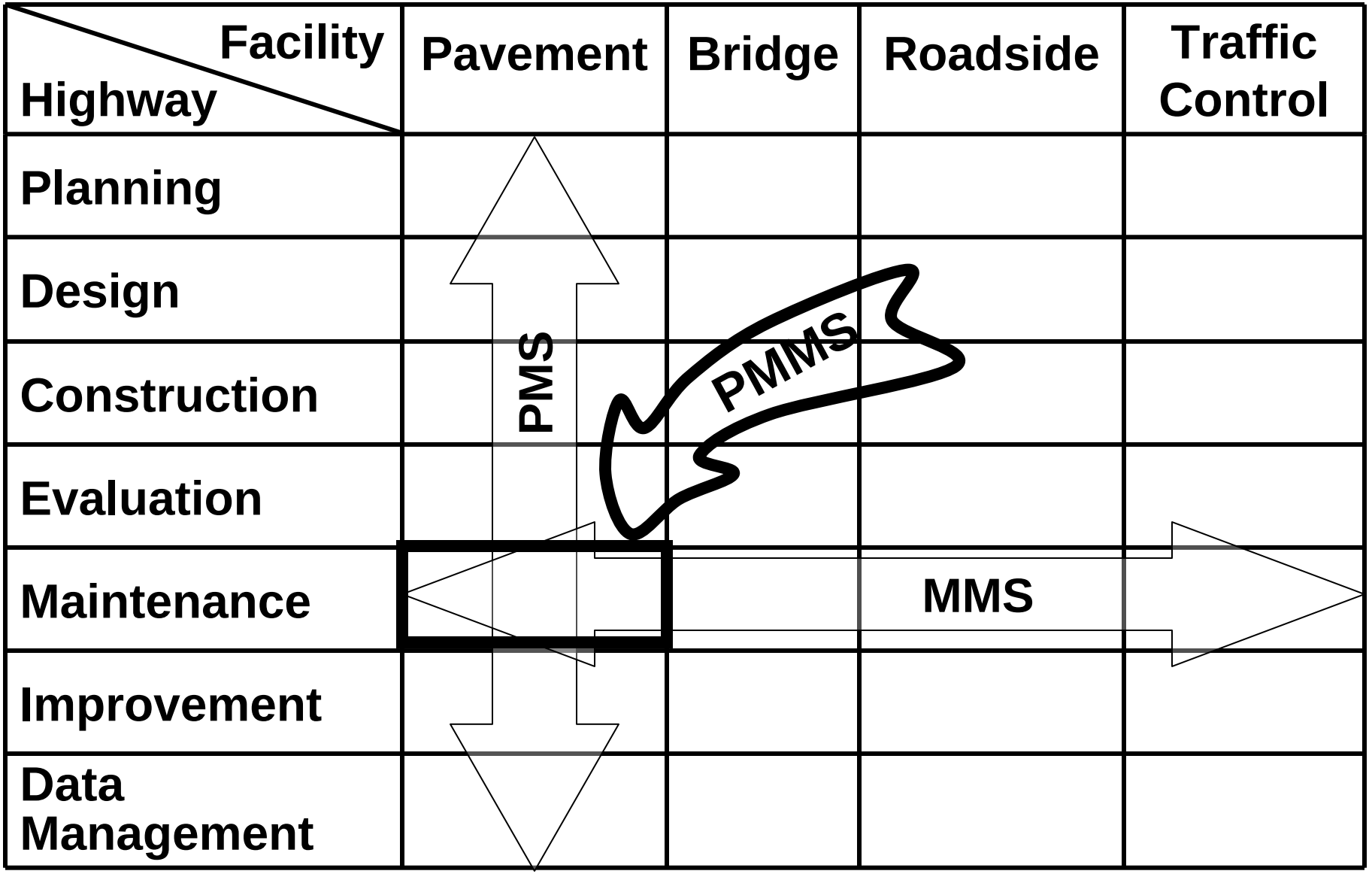
Rehabilitation

- Strategy
- Maintenance-Rehab trade-off
- Programming
- Scheduling

Reconstruction

- Widening
- Re-alignment
- Reconstruction vs overlay

PMS, PMMS and MMS



Requirements for Effective Pavement Management

- Availability of good and up-to-date information
- Good use of the state-of-the-art technology
- Tailored to fit into existing highway agency administrative structure
  - Computer
  - Test methods and equipment
  - Engineering knowledgement
- Continuous feedback and periodic evaluation
- Coordination between different levels of pavement management

Levels of Pavement Management

Project level PMS deals with the management of a single highway pavement, such as a toll road, an access road, or a car park.

Network level PMS handles a road network that typically comprises different road classes and pavement types.

A third level, variably known as **planning level**, **policy level** or **central office level**, is sometimes identified to highlight the budgeting process and fund-allocation decision making at the highest level of the management structure.

Levels of Pavement Management

Questions asked at **Planning Level**:

- What is the needed fund?
- What is the available amount of fund?
- What are the consequences of different funding levels?
- What are the impacts on users and non-users?

Main concerns at **Network Level**:

- Current network pavement condition
- Current level of service
- Priority setting of maintenance and rehabilitation
- Programming of activities
- Future level of service at given budget

Levels of Pavement Management

Main concerns at **Project Level**:

- Current pavement condition
- Type of maintenance
- Level of maintenance
- Rehabilitation strategy
- Overlay or reconstruction
- Future performance at given budget

Activities in a PMS Process

Consider the management of a single highway pavement (i.e. management at project level) beginning from the time when approval and funds to build the facility are given. Activities involved are:

(A) Planning

- Goals definition
- Data acquisition (terrain, traffic, soil, climate, materials, land use, facility & resources, inventories)
- Determination of broad route requirements (highway class, control points, constraints)
- Identification of major alternatives
- Evaluation & selection of 'best' plan
- Project schedule/program and budget

Activities in a PMS Process *(cont'd)*

(B) Design (Systems approach to pavement design)

- Route location/alignment analysis
- Alternative design strategies
- Pavement type selection analysis
- Material mix design (surface layer)
- Material selection/treatment (other pavement layers)
- Pavement thickness design
- Economic evaluation/optimisation -- Life cycle analysis (Construction policy, maintenance/ rehabilitation policy, performance prediction)

Activities in a PMS Process *(cont'd)*

(C) Construction

- Develop specifications
- Schedule construction operation
- Quality controls
- Construction records and documentation

(D) Evaluation & Monitoring of Pavement Conditions

- Pavement distress survey
- Pavement serviceability survey
- Skid resistance survey
- Structural condition survey
- Performance prediction model
- Remaining service life analysis

Activities in a PMS Process *(cont'd)*

(E) Maintenance & Rehabilitation

- Develop standards
  (Performance standards, effectiveness of repair)
- Trade-off analysis/optimisation/priority ranking
- Scheduling/programming of repair activities

References

- Chapter 18 “Pavement Management Systems” in The Handbook of Highway Engineering, edited by T. F. Fwa. (2006)
- Sinha K. C. and Fwa T. F. (1987) On the Concept of Total Highway Management. Transportation Research Record, No. 1229, pp. 79-88.