PAVEMENT MANAGEMENT SYSTEM
IMPORTANCE OF PAVEMENT MANAGEMENT SYSTEM

- Road System Deficient to Meet the Traffic Demand
- Improper Planning
- Deficiencies in Road Geometrics
- Poor Construction and Maintenance Practices
- Need for Proper Planning and Management of Resources
IMPORTANCE OF PAVEMENT MANAGEMENT SYSTEM

- Every Year Maintenance of Roads is Carried out
- Pavements Fail Pre-maturely
  - Improper Design
  - Poor Construction Practices
  - Wrong Maintenance Practices
  - Poor Drainage Maintenance
  - Frequent Cutting – Service Lines
PROBLEMS

- Difficult to Predict the Deterioration of Pavements
- Not Possible to Design Appropriate Maintenance Strategies
- Impossible to Prepare a Pavement Management System
• Vehicle Operation Costs Soar Due to Bad Roads
• Accidents Increase
• Limited Budgets
• Competing Demands
• Even small savings in VOC can Justify Very Large Investments
CHOICES

- Wide Range of Options in Materials and Design Techniques
- Choice in Maintenance Techniques
- Public Policies like Check on Truck Movements
- Desirable Performance Levels
PAVEMENT MANAGEMENT SYSTEM

- Indicate the Structure Needed to Prevent Acceptable Level of Deterioration during Design Life
- Permit Prediction of the Structural and Functional Condition Deterioration
IMPORTANCE OF PMS

- What Needs to be done for a Given Pavement?
- What are the Improvements Needed to Prevent Failure to Extend Pavement Life?
- In What Order and Where Should the Potential Projects be done?
- Given a Wide Range of Potential Projects which of the Projects be Taken up?
DEFINITION

“Pavement Management is Concerned with Doing Right Thing at the Right Place, Using the Right Type of Material, With the Right Thicknesses, With the Right Design Details and All for the Lowest Total Cost”
The Hatfield & McCoy Story

Two townships, One Destiny
HATFIELD Township

McCoy Township
Pavement Life

Hatfield

McCoy

Now

Now
Maintenance & Rehabilitation Plan

15 Total Miles

5 Years of Cycle

= 3 Miles Each Year

*Plus Required Preventive Maint. For Next 12 Miles
3 MILES/ YEAR
FOR
5 YEARS
+ REQUIRED GOOD MAINTENANCE
PAVEMENT LIFE

$1 to restore

$4-$5 to restore
Deferred Rehabilitation
Only "Urgent" Maintenance
DEFERRED REHABILITATION
-SAVES $ NOW-
1st Year Summary

$42,000 per mile x 3 miles

$126,000

+ 12 miles @ $5000 per

$186,000 Total
10 YEAR SUMMARY

FIRST 5 YEARS
$186,000
× 5
≈ 1 MILLION

NEXT 5 YEARS
$5,000/MILE
× 15 MILES
× 75,000
≈ 7.1 MILLION
10 YEAR SUMMARY

FIRST 5 YEARS → $45,000

NEXT 5 YEARS
$168,000/MILE × 15 MILES
2.52 MILLION

TOTAL $2.56 MILLION
GENERAL METHODOLOGY

- Identify the Deficiencies of Arterial and Sub-Arterial Roads
- Assess the Causes for the Poor Road Condition
- Work out PMMS considering Life Cycle Costs
- Plan and Develop a Maintenance Management System
PHASE - I

- Classify the Roads Based on Functional Hierarchy
- Identification of Structural and Functional Deficiencies
- Assess Maintenance Needs
PHASE - II

• Analysis of Structural and Functional Condition Evaluation
• Determination of Deficiencies
• Work out the Least Cost Solutions Considering Different Alternatives
• Economic Analysis
PHASE - III

- Consider Proposals for Execution, Quality Control
- Preparation of Data Base for PMMS
- Implementation & Monitoring
DATABASE

- Structural Condition Data – Deflection
- Riding Quality – Unevenness in mm/km
- Rating
- Drainage Requirements
- Traffic
- Footpath and Other Requirements
APPROACH

- Identify Road Stretches which are Structurally Deficient – I Stage Strengthening
- Identify Road Stretches having poor surface condition
- Classification of the sections based on structural adequacy
- Road Pavement stretches with localised failures
• Stretches with deficiencies with drainage requirements
• Stretches with large scale damages due to road cuttings
• Stretches requiring improvement in footpath
• Combination of any of the Above
SERVICE LIFE OF OVERLAY

- Depends on:
  - Structural Condition of the Existing Pavement
  - Road Maintenance Policy/Practice
  - Drainage
  - Traffic
  - Climatic and Environmental Factors
FIRST STAGE IMPROVEMENT

- Shift Existing service lines under the carriageway
- Provide service ducts
- Make profile correction
- Strengthen structurally inadequate pavements
- Resurface functionally inadequate pavements
- Rise the level of footpath and drains
STRENGTHENING AND RESURFACING

Priority – I

• Structurally weak pavements with high deflection and high unevenness

Priority - II

• Medium deflection and unevenness values
CALCULATE ROAD USER BENEFITS

• Vehicle Operating Cost Savings
  – Fuel, Parts, Tyres, Depreciation, Etc
• Travel Time Savings
• Reduction In Accidents
• Pavement Preservation
# Reduction in VOC Due to Road Surface Improvements on Roads of Different Widths

<table>
<thead>
<tr>
<th>VEHICLE TYPE</th>
<th>VOC CONSIDERING FUEL, TYRES AND SPARES, RS.</th>
<th>SINGLE LANE</th>
<th></th>
<th>INTERMEDIATE</th>
<th></th>
<th>TWO LANE</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>UI=8000 mm/km</td>
<td>UI=3000 mm/km</td>
<td>UI=8000 mm/km</td>
<td>UI=3000 mm/km</td>
<td>UI=8000 mm/km</td>
<td>UI=3000 mm/km</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>5.18</td>
<td>4.84</td>
<td>5.10</td>
<td>4.78</td>
<td>3.78</td>
<td>3.64</td>
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<tr>
<td>Truck</td>
<td>6.78</td>
<td>6.04</td>
<td>5.93</td>
<td>5.48</td>
<td>4.01</td>
<td>3.87</td>
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<tr>
<td>MAV</td>
<td>15.81</td>
<td>14.46</td>
<td>14.39</td>
<td>13.52</td>
<td>11.00</td>
<td>10.67</td>
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<tr>
<td>Jeep &amp; Maxi Cab</td>
<td>3.47</td>
<td>2.87</td>
<td>3.22</td>
<td>2.71</td>
<td>2.55</td>
<td>2.18</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>3.99</td>
<td>2.81</td>
<td>2.98</td>
<td>2.79</td>
<td>2.81</td>
<td>2.70</td>
<td></td>
</tr>
<tr>
<td>T/W</td>
<td>1.27</td>
<td>0.97</td>
<td>1.01</td>
<td>0.96</td>
<td>0.98</td>
<td>0.94</td>
<td></td>
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<tr>
<td>A/R</td>
<td>2.02</td>
<td>1.56</td>
<td>1.65</td>
<td>1.34</td>
<td>1.25</td>
<td>1.04</td>
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</tr>
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</table>
## Percentage Saving in VOC Due to Road Improvement Viz., UI 8000 to 3000 MM/KM and Widening of Carriageway

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Percentage Saving in VOC Due to Road Improvement</th>
<th>Single, UI = 8000</th>
<th>Single, UI = 3000</th>
<th>Two lane, UI = 3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td></td>
<td>6.56</td>
<td>29.73</td>
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<tr>
<td>Truck</td>
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<td>10.91</td>
<td>42.92</td>
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<tr>
<td>MAV</td>
<td></td>
<td>8.54</td>
<td>32.51</td>
<td></td>
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<tr>
<td>Maxi Cab/ Jeep</td>
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<td>17.29</td>
<td>37.18</td>
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</tr>
<tr>
<td>Car</td>
<td></td>
<td>29.70</td>
<td>32.46</td>
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<tr>
<td>Two-Wheeler</td>
<td></td>
<td>23.62</td>
<td>25.98</td>
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<tr>
<td>Auto-rickshaw</td>
<td></td>
<td>22.77</td>
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<td>48.51</td>
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</tbody>
</table>

*Note: UI Values are in mm/km*
### SAMPLE BENEFIT-COST ANALYSIS (Rs. Lakhs)

<table>
<thead>
<tr>
<th>Yr.</th>
<th>Cost of Improvement</th>
<th>Savings in VOC</th>
<th>Savings in Travel Time</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>82.5</td>
<td>427</td>
<td>1895</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>461</td>
<td>1622</td>
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<tr>
<td>3</td>
<td></td>
<td>498</td>
<td>1555</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>538</td>
<td>1490</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>582</td>
<td>1429</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>628</td>
<td>1370</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3134</td>
<td>9361</td>
</tr>
<tr>
<td>TOTAL BENEFITS</td>
<td></td>
<td>Rs. 12, 495 lakhs</td>
<td></td>
</tr>
</tbody>
</table>
CONCEPT OF PREVENTIVE MAINTENANCE

Rs. 1.00 for preventive maintenance here...

...delays spending Rs. 4.00 to Rs. 5.00 on more extensive treatments here.
ANOTHER OBJECTIVE OF PREVENTIVE MAINTENANCE

- Improve the overall pavement condition of the network

![Graph showing the comparison between Preventive Maintenance Program and Existing Program over age and condition.](image-url)
PAVEMENT CONDITION

Preventive Maintenance

Reactive Maintenance

Pavement Condition

Time or Traffic
A graph showing the decline in quality over time. The graph is labeled with categories from top to bottom: EXC, GOOD, FAIR, POOR, V. POOR, FAILED. The horizontal axis is labeled TIME.

Key points:
- 40% Drop in Quality at the 75% of Life mark.
- 12% of Life at the point where the curve begins to steeply decline.
- $1.00 for Rehab Here
- Will Cost $4.00 to $5.00 Here

Additionally, there is a note in the upper right corner saying "a Fraction of $1.00."
NETWORK ANALYSIS

- Identification and ranking of candidate pavements for improvements
- Network-level budgeting
- Long range budget forecasts
- Network – level pavement condition assessments
- Forecast of future conditions
PROJECT LEVEL

- Assessing the causes of deterioration
- Determining potential solutions
- Assessing benefits of the alternatives by life-cycle costing
- Ultimately selecting and designing the desired solutions
PRIORITY PROGRAMMING

- Information on Serviceability, Distress, Pavement Condition Data, Traffic and Environmental Data and Costs
- Deterioration Models
- Present Needs and Future Needs
- Budget Constraints
- Priority Analysis
- Alternative Strategies
- Output Reports
Effect of funding levels on network performance

- **Arterial Roads**
- **Sub-Arterial Roads**
- **Other Roads**
EFFECT OF BUDGET LEVELS

The graph illustrates the effect of different budget levels on roughness over the years 1998 to 2004. The x-axis represents the years, while the y-axis shows the roughness percentage. The graph includes lines for 50%, 80%, and 100% annual budget improvement targets. The actual roughness values are indicated by the lines, showing how they converge towards the target over time.

Key observations:
- The 50% budget line shows a significant improvement by 2004.
- The 80% budget line converges towards the target by 2004.
- The 100% budget line is closest to the target, indicating optimal budget levels.

The graph effectively demonstrates how budget levels impact roughness and how increasing budget levels can lead to better outcomes.
OPTIMAL BUDGET REQUIREMENTS

Rs. in m/year

Development

Improvement

Periodic

Routine

2000 2001 2002 2003
MAINTENANCE AND IMPROVEMENT COSTS

- Routine and recurrent maintenance costs
  - Budget MUST be sufficient otherwise re-specify
- Periodic maintenance costs
  - For specified alternatives
- Improvement costs
  - For specified alternatives
DETERMINE OPTIMUM STANDARDS

- Select optimum maintenance standards for each matrix cell under specified budget constraints
- Calculate total routine, recurrent and periodic maintenance costs for each cell
- Summarise total maintenance requirements for whole network
BUDGET ALLOCATION

- Routine maintenance needs based on road lengths under each category of roads
- Recurrent maintenance needs based on pavement surface condition
- Periodic maintenance needs based on economic indicators
- Improvement needs based on economic indicators
HDM-4 TECHNICAL IMPROVEMENTS

- **Pavements**
  - Wider range of flexible pavements
  - Rigid pavements
  - More maintenance types
  - Drainage effects
  - Freezing climates effects

- **Road Users**
  - New vehicle types
  - Characteristics of Modern Vehicles
  - Non-motorized traffic
  - Congestion effects
  - Accidents
  - Emissions & Energy consumption
THE HDM-4 MODEL

- Analytical tool for engineering and economic assessment of
  - Road investments and maintenance
  - Transport pricing and regulation

- Physical and economic relationships derived from extensive research on road deterioration, the effects of maintenance activities, and vehicle operation and user costs
ROAD AGENCY ALTERNATIVES

- Standards / Alternatives
  - Policies / Strategies
  - Norms / Options

- 4 cm overlay every 8 years
- 6 cm overlay every 15 years
- reseal the road and postpone the overlay
- reconstruct the road when IRI = 10
- do nothing

- grading every 180 days
- upgrade unpaved road to a paved standard
EVALUATION OF ALTERNATIVES

- Economic evaluation
- Technical evaluation
- Institutional evaluation
- Financial evaluation
- Commercial evaluation
- Social evaluation
- Environmental evaluation
ROAD USER COSTS MODEL

Road Geometry, Condition

Driver, Traffic Flow

Vehicle Characteristics

SPEED

Fuel & Lubricants
Tyre
Maintenance Parts & Labor
Crew Time
Depreciation & Interest
Passenger & cargo time
PAVED ROAD DETERIORATION MODEL

Moisture, Temperature, Aging

Pavement Materials, Thickness

Cracking, Ravelling, Potholing, Rutting, Roughness

Traffic, Loading
COSTS-SHARES UNDER OPTIMAL MAINTENANCE

50 veh/day  300 veh/day  5000 veh/day

User Costs
Agency Costs
User Costs
PRIMARY FEATURES OF HDM-4

• Simulates deterioration and maintenance of paved and unpaved roads, in physical condition and quantities, for strategies defined by the user

• Simulates road user costs (speeds and consumption of physical components)

• Determines time-streams of road agency, road user costs, and net benefits

• Computes economic indicators
## IMPORTANT USES OF HDM-4

<table>
<thead>
<tr>
<th>Planning and Programming</th>
<th>Technical Applications</th>
<th>Economic Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical support to justify funding</td>
<td>Forecasting financial and physical needs for preserving road network</td>
<td>Optimal maintenance strategies</td>
</tr>
<tr>
<td></td>
<td>Economic thresholds for road improvements</td>
<td>Simulating type and extent of deterioration</td>
</tr>
<tr>
<td></td>
<td>Tradeoffs between design and maintenance standards or options</td>
<td>Road use cost and damage attribution, in road transport pricing and taxation (user charges, fuel tax, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optimal axle loading and configuration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fleet modernization</td>
</tr>
</tbody>
</table>
## COMPARISON OF ALTERNATIVES

- Evaluation Period = 20 years
- Discount rate = 12.00%

<table>
<thead>
<tr>
<th>Length (km)</th>
<th>Construction Costs Alt</th>
<th>Maintenance Costs</th>
<th>Road User Costs</th>
<th>Total Costs</th>
<th>Net Present Value</th>
<th>Internal Rate of Return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>BASE 2.71</td>
<td>26.7</td>
<td>26.7</td>
<td>29.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROJ</td>
<td>9.28</td>
<td>17.0</td>
<td>26.2</td>
<td>3.2</td>
<td>17.1</td>
<td></td>
</tr>
</tbody>
</table>

Is the project economically justified?
MAINTENANCE NEEDS FORECASTING

- Routine Maintenance
  Reconstruction when IRI > 11.0

- Routine Maintenance
  Patching 100% of potholes
  Reconstruction when IRI > 11.0

- Routine Maintenance
  Patching 100% of potholes
  12 mm Resealing when damage is > 30%
  Reconstruction when IRI > 11.0

- Routine Maintenance
  Patching 100% of potholes
  4 cm overlay when IRI is > 4.0

- Routine Maintenance
  Patching 100% of potholes
  8 cm overlay when IRI is > 4.0
- What are the resources needed to maintain the network?

- How should the agency allocate the resources needed for an optimal maintenance program?

- What maintenance program should be implemented in case of budgetary constraints?
A Road Network

Resource Constraints

Optimal Strategy under Budgetary Constraints

Optimization Module

Strategy without Budget Constraint
ROLE OF HDM-4 IN ROAD MANAGEMENT

**INPUTS**
- Road Inventory
- Road Condition
- Traffic Data
- Bridges Inventory
- Bridges Condition

**DATABASES**

**OUTPUTS**
- Long Term Strategic Road Plan
- Multi-Year Rolling Work Program
- Detailed Project Level Appraisal
- Policies Standards Research Design
APPLICATIONS OF PAVEMENT MANAGEMENT SYSTEM

- Understanding Network Extent and Usage
- Analysing Current Network Condition
- Analysing Network Historical Condition
- Analysing Funding Options
- Decision Making and Marketing
- Interaction Between Top Management and Politicians
APPLICATIONS OF PAVEMENT MANAGEMENT SYSTEM

• Interaction Between Public, Legislators and Top Management
• Developing Single and Multi-year Programs
• Establishing Treatment Selection Methodologies
• Applications in Construction, Design and Materials
• Applications in Maintenance
• Applications in Research
Thank You...