HDM-4 Introduction
Transport and Development

- Transport sector is vital for economic & social development
- Roads constitute largest component of transport
- Roads require a balance of:
  - Maintenance (or Preservation)
  - Improvement (or Development)
- Objective of Road Management
  - Consistent and Rational Policy Objectives
  - Sufficient and Reliable Funding
  - Effective Procedures & Management Tools (e.g. HDM-4)
Road Management

• Purpose:
  - To optimise the overall performance of the network over time in accordance with POLICY OBJECTIVES and within budgetary constraints

• Typical objectives:
  - Minimise transport costs
  - Preserve asset value
  - Provide and maintain accessibility
  - Provide safe and environmentally friendly transport
Road Management Functions

- **Planning**
  - Setting standards and policies
  - Long term estimates of expenditure

- **Programming**
  - Medium term work programmes

- **Preparation**
  - Detailed project design and work packaging

- **Operations**
  - Implementation of works in field
HDM-4 Objectives (1)

Economic basis for selecting investment alternatives

Road standards

Pavement standards

Alignments
HDM-4 Objectives (2)

Minimize Road Agency and Road User Costs

- Non-motorized transport facilities
- Traffic congestion
- Vehicle emissions
- Travel times
- Transport costs
- Road accidents
HDM-4 Concept

• Predicts road network performance as a function of
  - Traffic volumes and loading
  - Road pavement type and strength
  - Maintenance standards
  - Environment / Climate

• Quantifies benefits to road users from:
  - Savings in vehicle operating costs (VOC)
  - Reduced road user travel times
  - Decrease in number of accidents
## Role of HDM-4

<table>
<thead>
<tr>
<th>Management Function</th>
<th>HDM-4 Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Strategy Analysis</td>
</tr>
<tr>
<td>Programming</td>
<td>Programme Analysis</td>
</tr>
<tr>
<td>Preparation</td>
<td>Project Analysis</td>
</tr>
</tbody>
</table>
HDM-4 Applications

• Road sector policy studies
• Strategic planning of road network development, improvement & maintenance
• Determination of funding requirements
• Preparation of multi-year road work programmes
• Economic appraisal of individual road projects
• Research studies
  - Road pricing
  - Vehicle regulations
  - Pavement design standards
HDM-4 Tool

• 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
HDM-4 Life Cycle Analysis

Input Data

Predict Road Deterioration

Predict Road Work Effects

VOC, Accident & Time costs

Discount Annual Costs & Compare

Repeat for all years

Output NPV, IRR,..
Comparison of Project Alternatives

Discounted RAC
(Road works + RUC)

With Overlay

Without Overlay

Project Life (years)
End of Analysis
Comparison of Project Alternatives

- Cost of Paving
- Without Paving
- Discounted RAC
- RUC
- NPV
- Project Life (years)
- End of Analysis
HDM-4 History

de Weille 1966

Highway Cost Model 1971

Kenya Study 1971-75

Caribbean Study 1977-82
India Study 1976-82
Brazil Study 1975-84

HDM-II 1981

HDM-III 1987

HDM-4 2000 ISOHDM

RTIM (TRRL)

RTIM2 (TRL)

RTIM3 (TRL)
International Collaboration

• 1969-1995 – HCM, HDM-II, HDM-III
  - Collaborative international studies
    World Bank & MIT, LCPC, TRRL, UNDP
  - Governments of Kenya, Brazil, Caribbean, India
  - $20 million data collection in 4 field studies
• 1995-2005 – HDM-4 version 1.0 to 1.3
  - International sponsors, PIARC
  - Redesign of functions and software
  - Focus on road agency usage
• 2006-> HDM-4 version 2.0
  - HDMGlobal International Consortium
    responsible for management as sales
<table>
<thead>
<tr>
<th>Year Period</th>
<th>Phase/Study</th>
<th>Activities/Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969-1971</td>
<td>Phase 1</td>
<td>Conceptual Framework</td>
</tr>
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<td>First Prototype</td>
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<td>MIT, TRRL</td>
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<td>1971-1975</td>
<td>Kenya Study</td>
<td>VOC Study</td>
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<td>Road Deterioration Study</td>
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<td>TRRL</td>
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<td>1977-1982</td>
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<td>VOC Study</td>
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<td>1977-1983</td>
<td>India Study</td>
<td>VOC Study</td>
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<td>1975-1982</td>
<td>Brazil Study</td>
<td>VOC Study</td>
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<td>Road Deterioration Study</td>
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<td>GEIPOT</td>
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<td>United Nations</td>
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<td>1981-1987</td>
<td>Final Phase</td>
<td>Modeling</td>
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<td>1987</td>
<td>HDM-III Publications</td>
<td>Research Documentation</td>
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<td>The World Bank</td>
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<td>1989</td>
<td>HDM-III Software</td>
<td>PC Computer software</td>
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<td></td>
<td></td>
<td>The World Bank</td>
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<td>1995</td>
<td>HDM System</td>
<td>Congestion, HDM Manager</td>
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<td></td>
<td>The World Bank</td>
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</tbody>
</table>
HDM-4 Sponsors

- Overseas Development Administration (ODA/DFID)
- Asian Development Bank (ADB)
- Swedish National Road Administration (SNRA)
- Inter-American Federation on Cement Producers (FICEM)
- The World Bank (IBRD)
- The World Road Association (PIARC)

Steering Committee
(World Bank)
Secretariat
The University of Birmingham

Other Contributors

Technical Advisors

ODA
The University of Birmingham

ADB
N D Lea Int.
IKRAM

SNRA
SweRoad
VTI

FICEM
ICH (Chile)
Catholic Univ.
HDM-4 Version 1.0 Coordination

- In 1998 The World Road Association (PIARC) took responsibility for coordinating the international implementation of the Highway Development and Management System (HDM-4) Version 1.0

PIARC  
Web: http://hdm4.piarc.org  
Email: piarc.hdm4@ibm.net  
Fax: 33-1+49 00 02 02
HDM-4 Version 2.0 Coordination

- In 2005 PIARC awarded a five year concession to HDMGlobal for the future management of HDM-4 with exclusive rights for its distribution.
- HDM4Global is an international consortium of academic and consultancy companies that have formed a partnership.
- At the center of consortium is the Highway Management Research Group a UK based association of the University of Birmingham, Atkins and Scott Wilson in partnership with; TRL Ltd also of the UK, ARRB Transport Research Ltd from Australia, ENPC and Scetaouroute from France, and ICH of Chile.
HDM-4 Version 2.0 Distribution

The HDMGlobal distributor role is to:
• sell the software license and deliver HDM-4 on CD-ROM
• deliver updates on disk or by internet download
• provide first contact support

Website: http://hdmglobal.com/

E-mail: presses.ponts@mail.enpc.fr or sales@hdmglobal.com.
The HDM-4 Products on CD ROM

- HDM-4 software
- Case study data sets
- HDM Series documents
HDM-4 Series Collection

Volume 6: Modeling Road Deterioration and Works Effects
Volume 7: Modeling Road User and Environmental Effects
## HDM-4 Version 2.0 Prices (US$)

<table>
<thead>
<tr>
<th>Package Type</th>
<th>Standard</th>
<th>Developing Countries*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single License**</td>
<td>3,450</td>
<td>2,300</td>
</tr>
<tr>
<td>Four Pack or more</td>
<td>2,930</td>
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</tr>
<tr>
<td>Five Pack or more</td>
<td>2,760</td>
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</tr>
</tbody>
</table>

* per capita GNI of less than USD3,255 equivalent per year

** can be installed on two desktop computers
Minimum System Requirements

• Pentium P100 processor (or equivalent)
• 32MB of RAM
• 30MB of hard disk space (for program and documentation)
• 50MB of hard disk space (for storage of run-data)
• Windows XP, 95/98 or NT 4 with Service Pack 6a installed
• Desktop software. No server version available
Limitations of HDM-III

- Vehicle and tire technology in the VOC studies bears little resemblance to those of modern vehicles
- HDM-III does not consider:
  - Traffic congestion (prior to 1995)
  - Rigid pavements
  - Many types of flexible pavements
  - Pavement texture and skid resistance
  - Freeze-thaw conditions
  - Traffic safety
  - Environmental impacts
- Software for DOS environment
HDM-4 Technical Improvements

- 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
HDM-4 Software Improvements

- Windows 95/98/NT Environment
  - Easy to use
  - Different levels of input data
- Three Application Modules
  - Project Evaluation
  - Network Programme Evaluation
  - Network Strategic Planning Evaluation
- Better interface with Pavement Management Systems
HDM Version 1.3 and 2.04

- 100% same input data
- 99.9% same results with same inputs
- 100% same output reports
- Overall same structure
- HDM-4 version 2.04 new features:
  - Sensitivity analysis
  - Asset value calculation
  - Storage of different budget scenarios results
  - Some input data rearranged (e.g. traffic composition entered together with daily traffic)
  - Exports/Import data to Access files
Comparison of Alternatives

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

- Paved road alternatives, e.g.:
  - overlay at specified condition or time
  - reseal first and overlay later
  - reconstruct at specified condition or time
  - do nothing or do minimum (patching)
  - widen pavement at specified time or V/C
  - improve alignment or add lane

- Unpaved road alternatives, e.g.:
  - grading every 180 days
  - upgrade to paved standard at time or condition
Evaluation of Alternatives

- Economic evaluation
- Technical evaluation
- Institutional evaluation
- Financial evaluation
- Social evaluation
- Environmental evaluation

*Political evaluation*

HDM-4 Main Focus
Transport Benefits

• Reduce vehicle operating cost
• Savings in time of passengers and cargo
• Reduction of accidents
• Stimulate regional development

• Increase the comfort and convenience
• Better national integration
• National security
• Greater self-sufficiency
• Equal distribution of income
• Prestige of the country

HDM-4 Benefits
The Beginning, 1969

- More than 10,000 million dollars are spent on the highway sector each year in developing countries. The cost borne by the road-using public for vehicle operation are typically 8 to 10 times greater.

- In Europe and North America:
  - high traffic volumes
  - high values attached to travel time savings
  - relatively abundant capital resources
  - roughness is generally not an issue

- In developing countries:
  - traffic levels often much lower
  - values given to travel time savings are far lower
  - acute shortage of financial resources
  - roughness is a main issue
Pavement Management Approaches

- **Crisis-oriented approach**
  highway facilities are operated with little or no maintenance until obstructive failure occurs that needs extensive restoration and reconstruction work

- **Condition-responsive/financial approach**
  physical standards are set in relation to:
  a) perceived technical requirements, b) acceptable service levels, and c) received budget

- **Technical-economic efficiency approach**
  functional and technical standards are selected to minimize total road transport costs to society.

HDM-4 Approach
Technical-economic Efficiency

- Current Condition
- Deterioration Prediction
- Maintenance Effects
- Vehicle Operating Costs

Terminal Life or Condition Limit?

Benefits to Society?

Worst First?

Overall Index

Ride m/km
Distress %
Rut mm
Structural #
Safety #

Index Rating

90 Poor

R.E.

HDM-4 Approach

Current Condition

Deterioration Prediction

Remaining Service Life
Total Society Costs

= ROAD AGENCY COSTS

  o Construction
  o Maintenance

+ ROAD USER COSTS

  o Vehicle operation
  o Passenger and cargo time
  o Accidents
Total Society Costs Composition

CONSTRUCTION
- Pavement
- Structures
- Furniture
- Formation
- Land

MAINTENANCE
- Routine
- Pavement
- Structures

SYSTEM OPERATION
- Traffic mgt.
- Safety
- Management

ROAD USERS
- Fuel, lubricants
- Maintenance
- Depreciation
- Time
- Accidents

EXTERNAL
- Accidents
- Pollution
- Access
- Production
Minimizing Total Society Costs

Cost

Total

Optimum

Road User

Road Works

Design Standards
Minimizing Resource Consumption

Consumption of Resources X Unit Costs = Total Society Costs
Financial & Economic Unit Costs

- Financial Prices
  - Market Prices

- Economic Prices
  - Shadow Prices
  - Social Prices

Do not reflect the real scarcity value of the inputs

Developing Countries
- Government Controls
  - Taxes
  - Subsidies
  - Regulations
- Rapid Inflation
- Overvaluation of Domestic Currency
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 resources)
- Determines time-streams of road agency, road user costs, and net benefits
- Computes economic indicators
Paved Road Deterioration Model

Moisture, Temperature, Aging

Traffic, Loading

Pavement Materials, Thickness

Cracking
Ravelling
Potholing
Rutting
Roughness
Road User Effects
Road User Costs Model

Road Geometry, Condition

Driver, Traffic Flow

Vehicle Characteristics

SPEED

Fuel & Lubricants
Tire
Maintenance Parts & Labor
Crew Time
Depreciation & Interest
Passenger & cargo time
Road User Costs

- Car
- Pickup/utility
- Bus
- Heavy Truck
- Rickshaw

Road User Costs ($/veh-km) vs. Road Condition (IRI)

- Good
- Poor
Optimal Maintenance Costs-shares

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

User Costs

Agency Costs
HDM-4 Limitations

• The model accepts but does not perform network traffic assignment

• Limited estimation of environmental impacts, such as air pollution, and not costed internally

• Only partially applicable to urban traffic conditions – through acceleration variance

• Option for evaluating cement blocks and cobblestone pavements not yet implemented
### Important Uses of HDM-4

<table>
<thead>
<tr>
<th>Planning and Programming</th>
<th>Analytical support to justify funding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forecasting financial and physical needs for preserving road network</td>
</tr>
<tr>
<td>Technical Applications</td>
<td>Optimal maintenance strategies</td>
</tr>
<tr>
<td></td>
<td>Economic thresholds for road improvements</td>
</tr>
<tr>
<td></td>
<td>Tradeoffs between design and maintenance standards or options</td>
</tr>
<tr>
<td></td>
<td>Simulating type and extent of deterioration</td>
</tr>
<tr>
<td>Economic Applications</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>Optimal axle loading and configuration</td>
</tr>
<tr>
<td></td>
<td>Fleet modernization</td>
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</tbody>
</table>
Planning

• Medium- & long-term evaluation of options & strategies: 4-, 5-, 6- or 10-yrs
• Outputs:
  - Program allocations by network & region (routine m., periodic m, rehab., betterment, etc.) - approximate quantity, cost, benefit
  - Outcome in performance
  - Major development schemes identified and preparation scheduled
Programming

• Annual or 2-3-yr rolling program prepared for each network, within imposed budget allocations

• Output:
  - individual projects identified in each program, network & region
  - cost and benefit estimates

• Network-Level Analysis
Project Preparation

- Comparison of project-alternatives, economic justification:
  - pre-feasibility study
  - feasibility study

Technical Standards

- Definition of road agency norms and policies:
  - Levels of service
  - Recommended works
  - Trigger points