

H D M - 4

HIGHWAY DEVELOPMENT & MANAGEMENT

volume four

Analytical Framework and Model Descriptions

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4

THE HIGHWAY DEVELOPMENT AND MANAGEMENT SERIES

About This Manual

This Version 2 edition of the [Analytical Framework and Model Descriptions](#) describes the analytical framework and the technical relationships of objects within the HDM-4 model. It contains very comprehensive reference material describing, in detail, the characteristics of the modelling and strategy incorporated in HDM-4.

It is to be used by specialists or experts whose task is to carry out a detailed study for a road management organisation. The [Analytical Framework and Model Descriptions](#) is one of five manuals comprising the suite of HDM-4 documentation (see Figure 1).

The suite of documents comprise:

- **Overview of HDM-4 (Volume 1)**

A short executive summary describing the HDM-4 system. It is intended to be used by all readers new to HDM-4, particularly high level management within a road organisation.

- **Applications Guide (Volume 2)**

A task oriented guide describing typical examples of different types of analyses. It is to be used by the frequent user who wishes to know how to perform a task or create a study.

- **Software User Guide (Volume 3)**

Describes the HDM-4 software. It is a general purpose document which provides an understanding of the software user interface.

- **Analytical Framework and Model Descriptions (Volume 4)**

Describes the analytical framework and the technical relationships of objects within the HDM-4 model. It contains very comprehensive reference material describing, in detail, the characteristics of the modelling and strategy incorporated in HDM-4. It is to be used by specialists or experts whose task is to carry out a detailed study for a road management organisation.

- **A Guide to Calibration and Adaptation (Volume 5)**

Suggests methods for calibrating and adapting HDM models (as used in HDM-III and HDM-4), to allow for local conditions existing in different countries. It discusses how to calibrate HDM-4 through its various calibration factors. It is intended to be used by experienced practitioners who wish to understand the detailed framework and models built into the HDM-4 system.

- **Modelling Road Deterioration and Works Effects (Volume 6)**

Describes the technical background of theory, observation, knowledge and international practice in which the HDM-4 models for road deterioration and works effects have been developed.

- **Modelling Road User and Environmental Effects (Volume 7)**

Describes the technical background of theory, observation, knowledge and international practice in which the HDM-4 models for road user and environmental effects have been developed.

Notes:

- 1 Volumes 1, 2 and 3 are designed for the general user.

- 2 Volumes 4, 5, 6 and 7 will be of greatest relevance to experts who wish to obtain low level technical detail. However, Volume 5, in particular, presents very important concepts, which will be of interest to all users.

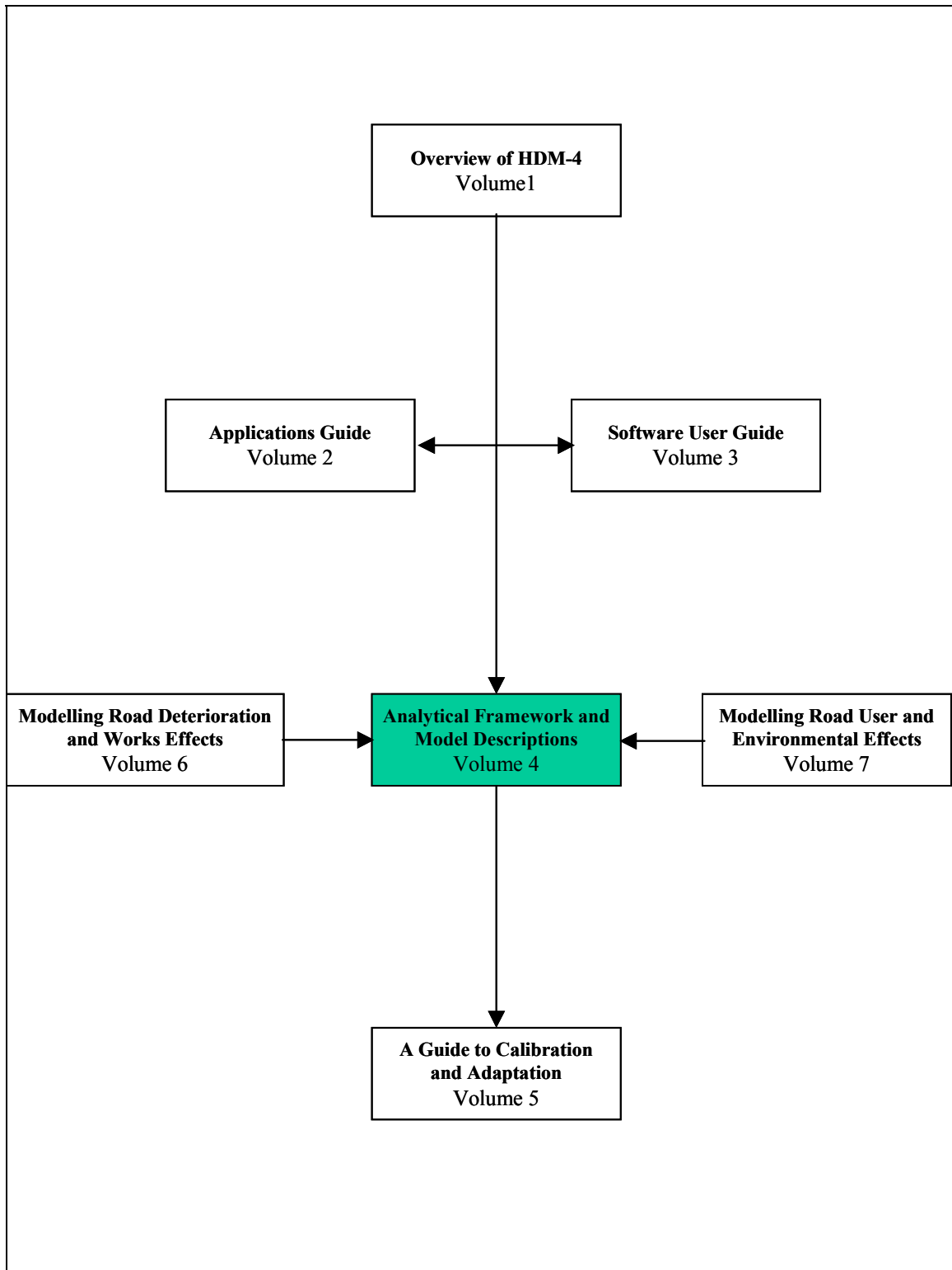


Figure 1 HDM-4 documentation suite

Structure of the ‘Analytical Framework and Model Descriptions’

The information in the [Analytical Framework and Model Descriptions](#) is structured in seven parts (see Figure 2).

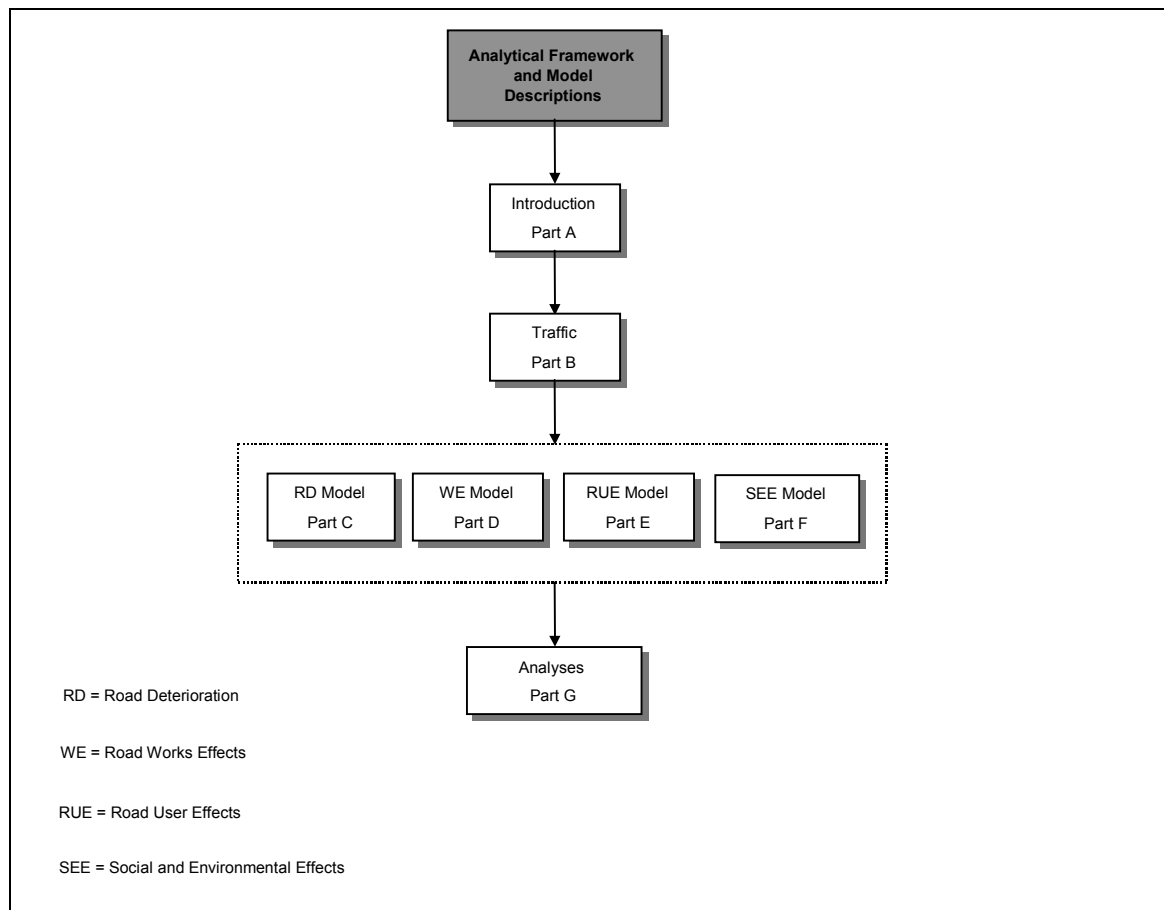


Figure 2 The Analytical Framework and Model Descriptions documentation

The seven parts in the [Analytical Framework and Model Descriptions](#) contain the following information:

- **Part A - Introduction**

Provides an overview of the [Analytical Framework and Model Descriptions](#).

- **Part B - Traffic**

Describes the traffic characteristics used in HDM-4, and provides details of the traffic data that is required.

- **Part C - Road Deterioration Models**

- ❑ C1 Modelling Concepts and Approach

Describes the types of pavements modelled in HDM-4, and the possible combinations of pavement surface types and base types. It discusses the key variables that affect deterioration, which include climate and environment effects, traffic, and pavement history.

- ❑ C2 Bituminous Pavements

Describes the specifications used in the Bituminous Pavements (**Road Deterioration**) model. It provides a detailed discussion of pavement materials, surface behaviour, surface distress, pavement strength, and construction quality.

- ❑ C3 Concrete Pavements

Describes the specifications used to model rigid (or Portland) cement concrete pavements. This includes details of the different types of rigid concrete pavement construction that are modelled in HDM-4.

- ❑ C4 Unsealed Roads

Describes the specifications used in the unsealed Road Deterioration models. It provides an overview of the HDM-4 Road Deterioration modelling logic, and the relationships and default coefficient values for each of the distresses modelled.

- **Part D - Road Works Effects**

- ❑ D1 Types of Works

Describes the types of road works and their effects on road pavements, including the calculation of physical quantities of road works and the corresponding costs.

The three types of pavements considered are:

- 1 Bituminous pavements (see Chapter D2)
- 2 Concrete pavements (see Chapter D3)
- 3 Unsealed roads (see Chapter D4)

- ❑ D2 Bituminous Pavements

Describes the detailed modelling of **Road Works Effects** for bituminous pavements. This includes methods of defining works activities and intervention criteria, the calculation of physical quantities of road works and their corresponding costs, and the effects of road works on pavement characteristics and road users. Road works are grouped into the following classes:

- Routine maintenance
- Periodic maintenance
- Special works
- Improvement works
- Construction works

- ❑ D3 Concrete Pavements

Describes the detailed modelling of **Road Works Effects** for concrete pavements. This includes methods of defining works activities (maintenance and rehabilitation) and intervention criteria, and classification of the road works. The following three types of concrete pavements are analysed:

- 1 Jointed Plain Concrete Pavements
- 2 Jointed Reinforced Concrete Pavements
- 3 Continuously Reinforced Concrete Pavements

The following classes of road works are performed:

- Routine maintenance
- Restorations
- Overlays
- Reconstruction
- ❑ D4 Unsealed Roads

Describes the detailed modelling of road works effects for unsealed roads, including the methods of defining works activities and intervention criteria, the calculation of physical quantities of road works and their corresponding costs, and the modelling of the effects of road works on pavement characteristics and road users. Unsealed road works are grouped into the following classes:

- Maintenance
- Improvement works
- Construction works

■ Part E - Road User Effects

- ❑ E1 Introduction

Provides an overview of the implementation of Road User Effects (RUE) models for calculating motorised vehicle operating costs and travel time, including an overview of the HDM-4 representative vehicle framework and the default representative vehicle types.

- ❑ E2 Vehicle Speeds and Operating Costs

Describes the implementation of **Road User Effects** (RUE) models for calculating motorised vehicle speeds, operating costs and travel time. It provides an overview of the modelling concepts and logic, the relationships used, and the default parameter values for each of the RUE components.

- ❑ E3 Non-Motorised Transport

Discusses the use of non-motorised modes of transport and their effect on the motorised transport. The impact of non-motorised transport on other road users and road characteristics is included.

- ❑ E4 Road Safety

Describes the implementation of road safety models through a series of **look-up tables** of accident rates with user defined accident costs.

■ Part F - Social and Environmental Effects

- ❑ F1 Introduction

Gives an overview of the modelling logic used to quantify the energy consumed by both motorised and non-motorised vehicles, together with the emissions produced by motorised vehicles.

- ❑ F2 Energy Balance Analysis

Describes the energy implications of alternative transport projects and policies. The models estimate separately the global and national consumption of non-renewable

energy by motorised vehicles, the consumption of renewable energy by non-motorised vehicles, and energy use in roadworks.

- ❑ F3 Vehicle Emissions

Describes the models used to quantify vehicle emissions. The document presents the emissions models together with default parameters for the 16 standard vehicle types. Details of the input data and the output reports are also given.

- **Part G - Analyses**

- ❑ G1 Economic Analysis

Describes how the annual costs streams calculated by the HDM-4 components are compared to determine the benefits and costs associated with a road investment. Standard discounting methods are then applied to calculate key economic indicators such as net present values, internal rates of return and benefit/cost ratios. Investment optimisation methods are also described.

- ❑ G2 Sensitivity and Scenario Analysis

Describes how the user can investigate the impact of variations in key parameters on the analysis results.

- ❑ G3 Budget Scenario Analysis

Describes how to define budget scenarios using the road agency financial resources available over the analysis period. The document outlines how the user can compare the effects of different funding levels on the network being analysed.

- ❑ G4 Asset Valuation

Describes the methodology for road asset valuation. Estimates of road assets are calculated in financial and economic terms as a function of the level of investment. A road network is a considerable resource that has a significant asset value. It is therefore important to manage this asset effectively.

- ❑ G5 Multiple Criteria Analysis (MCA)

Describes how multi-criteria analysis can be used to compare projects using criteria that cannot easily be assigned an economic cost. The methodology provided is based on the Analytical Hierarchy Process (AHP).

ISOHDM Products

The products of the International Study of Highway Development and Management Tools (ISOHDM) consist of the HDM-4 suite of software, associated example case study databases, and the Highway Development and Management Series collection of guides and reference manuals. This Volume is a member of that document collection.

Customer contact

Should you have any difficulties with the information provided in this suite of documentation please do not hesitate to report details of the problem you are experiencing. You may send an E-mail or an annotated copy of the manual page by fax to the number provided below.

HDMGlobal welcomes any comments or suggestions from users of HDM-4. Comments on the [Analytical Framework and Model Descriptions](#) should be sent to the following address:

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Change details

A first edition of (Version 1) of Volume 4 was produced in 2000.

This is the second edition (Version 2.0) of the Volume 4 of the HDM-4 documentation.

HDM-4 documents:

The Highway Development and Management Series Collection is ISBN: 2-84060-058-7, and comprises:

Volume 1 - [Overview of HDM-4](#), ISBN: 2-284060-183-4

Volume 2 - [Applications Guide](#), ISBN: 2-284060-184-2

Volume 3 - [Software User Guide](#), ISBN: 2-284060-185-0

Volume 4 - [Analytical Framework and Model Descriptions](#), ISBN: 2-284060-186-9

Volume 5 - [A Guide to Calibration and Adaptation](#), ISBN: 2-84060-063-3

Volume 6 - Modelling Road Deterioration and Works Effects, ISBN: 2-84060-102-8

Volume 7 - Modelling Road User and Environmental Effects, ISBN: 2-84060-103-6

Terminology handbooks

PIARC Lexicon of Road and Traffic Engineering - First edition. Permanent International Association of Road Congresses (PIARC), Paris 1991. ISBN: 2-84060-000-5

Technical Dictionary of Road Terms - Seventh edition, English - French. PIARC Commission on Terminology, Paris 1997. ISBN: 2-84060-053-6

General reference information

Further details on HDM-4 may be obtained from the following:

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The development of HDM-4 has been sponsored by several agencies, primarily:

- **Asian Development Bank (ADB)**
- **Department for International Development (DFID) in the United Kingdom**
- **Swedish National Road Administration (SNRA)**
- **The World Bank**

In addition to these, significant contributions were made by:

- **Finnish National Road Administration (Finnra)**
- **Inter-American Federation of Cement Producers (FICEM)**

Many other organisations and individuals in a number of countries have also contributed in terms of providing information, or undertaking technical review of products being produced.

The study has been co-ordinated by the ISOHDM Technical Secretariat at the University of Birmingham in the United Kingdom. A number of organisations participated in the research including:

- **Finnra**
Specification of the strategic and programme analysis applications.
- **FICEM**
Development of deterioration and maintenance relationships for Portland cement concrete roads.
- **The Highway Research Group**, School of Civil Engineering, The University of Birmingham
Responsible for system design and software development.
- **Laboratoire Central des Ponts et Chaussées (LCPC)** in France
Responsible for overseeing the definition of the specifications for Version 2 and the software development.
- **Road Research Institute (IKRAM)** in Malaysia supported by N.D.Lea International (NDLI)
Responsible for providing updated relationships for road deterioration and road user costs.
- **TRL Limited** in the United Kingdom
Responsible for review and update of bituminous pavement and unsealed road deterioration relationships.
- **ARRB Group Ltd** in Australia
Responsible for review and update of bituminous pavement and unsealed road deterioration relationships.
- **SNRA**
Responsible for developing deterioration relationships for cold climates, road safety, environmental effects, and supporting HRG with system design.

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- Michael J. Riley (UK)

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Contents

Volume 4 - Analytical Framework & Model Descriptions

Part A Overview

A1	Introduction	A1-1
----	--------------	------

Part B Traffic

B1	Traffic characteristics	B1-1
----	-------------------------	------

Part C Road Deterioration Models

C1	Modelling concepts and approach	C1-1
C2	Bituminous Pavements	C2-1
C3	Concrete Pavements	C3-1
C4	Unsealed Roads	C4-1

Part D Road Works Effects

D1	Types of roadworks	D1-1
D2	Bituminous Pavements	D2-1
D3	Concrete Pavements	D3-1
D4	Unsealed Roads	D4-1

Part E Road User Effects

E1	Overview	E1-1
E2	Motorised Vehicle Speeds and Operating Costs	E2-1
E3	Non-Motorised Transport	E3-1
E4	Road Safety	E4-1

Part F Social and Environmental Effects

F1	Overview	F1-1
F2	Energy Balance Analysis	F2-1
F3	Vehicle Emissions	F3-1

Part G Analyses

G1	Economic Analysis	G1-1
G2	Sensitivity and Scenario Analysis	G2-1
G3	Budget Scenario Analysis	G3-1

G4 Asset Valuation	G4-1
G5 Multiple Criteria Analysis	G5-1

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Volume **five**: A Guide to Calibration and Adaptation

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Highway Development and Management Series

The Highway Development and Management system (HDM-4) provides a harmonised systems approach to road management, with adaptable and user-friendly software tools. It is a powerful tool for conducting project appraisals and analyses of road management and investment alternatives.

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