



Association
mondiale
de la Route



World Road
Association

A tool for investigating road investment choices

Jennaro B. Odoki

The University of Birmingham

- **Sponsors:**
 - **World Bank**
 - **Dept for International Development**
 - **Asian Development Bank**
 - **SNRA & Others**

- **In progress since 1993 comprising**
 - **technical studies (1993~1997)**
 - **software development and testing (1996~1999)**
 - **PIARC leading the implementation phase (1999 ~)**

Objectives:

Economic basis for selecting investment alternatives



Road standards



Pavement standards



Alignments

Objectives:

Minimise Road Agency and Road User Costs



**Non-motorised
transport facilities**



Traffic congestion

Vehicle emissions



Transport costs

Travel times



Road accidents

HDM-4 Analytical Framework

Predicts road network performance as a function of:

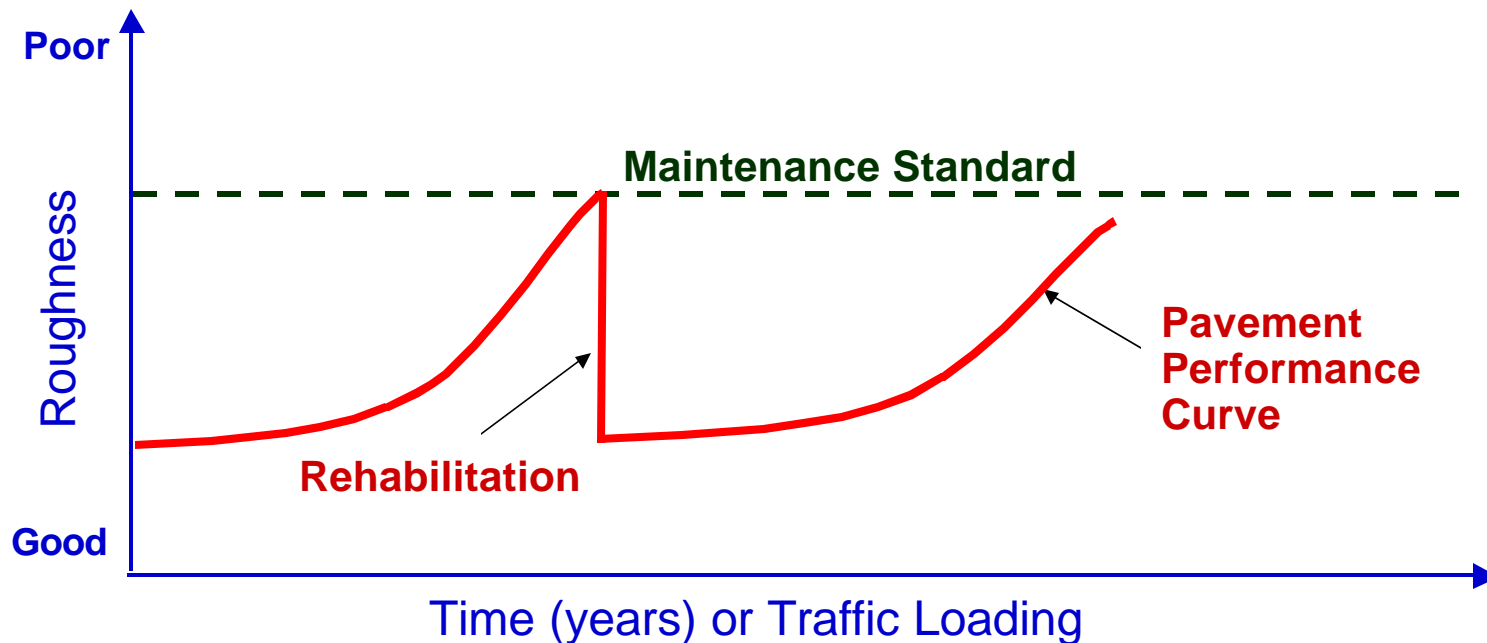
- **Traffic volumes and loading**
- **Road pavement strength**
- **Maintenance and improvement standards**
- **Environment**

Quantifies benefits to road users from:

- **Savings in vehicle operating costs (VOC)**
- **Reduced road user travel times**
- **Decrease in number of accidents**
- **Environmental effects**

Road Maintenance & Improvement

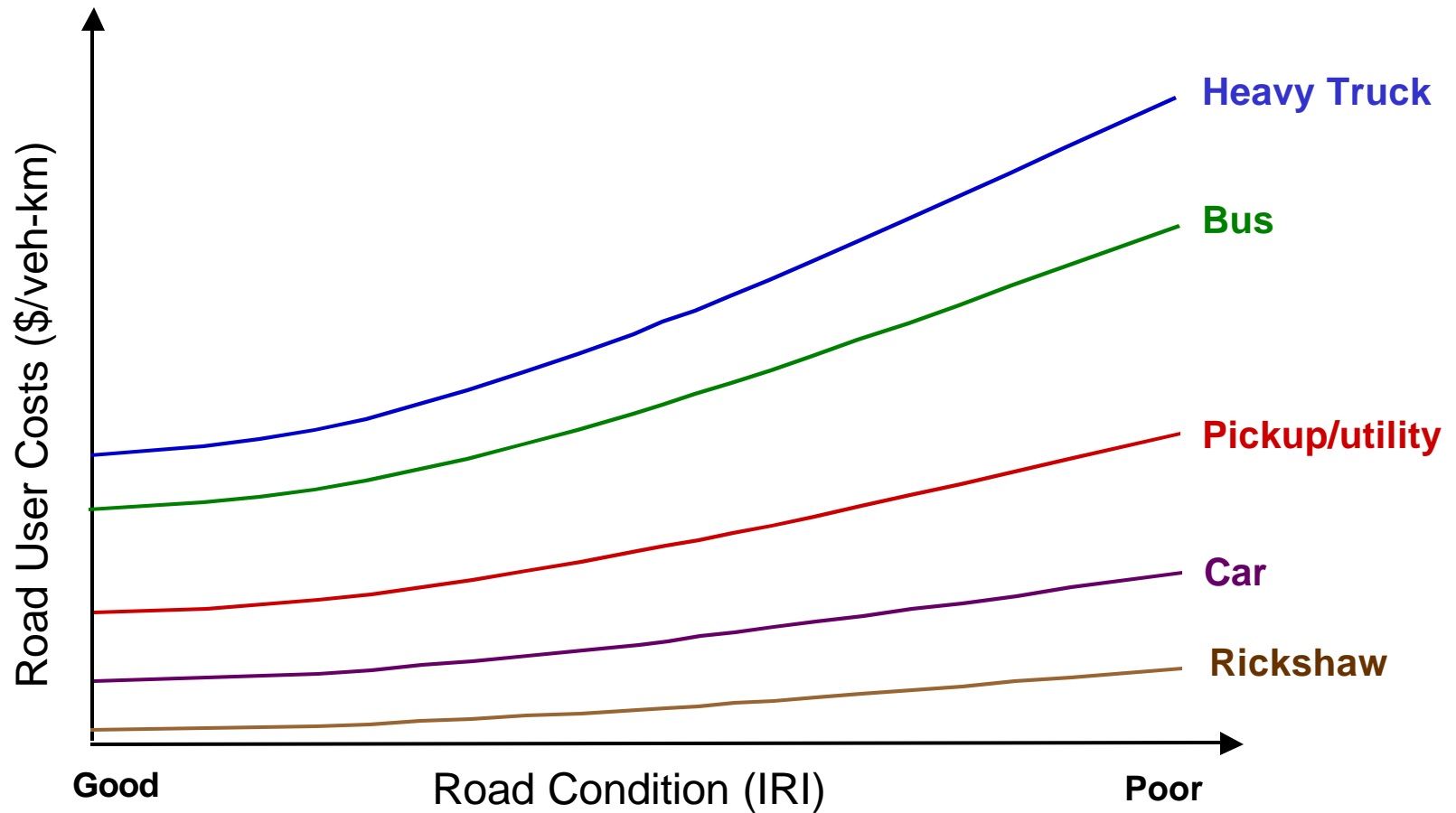
- Affects long term pavement performance
- Funding requirements depend on specified maintenance standards & unit costs



Road User Effects

- **Vehicle operating costs**
 - fuel, oil, tyres, parts consumption
 - vehicle utilisation & depreciation
- **Travel time**
 - passengers
 - cargo
- **Road accidents**
- **Energy consumption**
- **Vehicle emissions & noise**

Impact of Road Condition



EXOGENOUS BENEFITS AND COSTS

- **Due to other road related investments**
 - **diversion routes, bridge repair, slope stabilisation, etc.**
- **Development benefits**
 - **agricultural, commercial, industrial, etc.**
- **Accessibility benefits**
- **Environmental impacts (pollution, ecological)**
- **Social & resettlement impacts**



Association
mondiale
de la Route



World Road
Association

The Role of HDM-4 in Road Management

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 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**

Strategy Analysis

Strategy analysis is concerned with the analysis of entire road networks to determine funding needs and/or to predict future performance under budget constraints

Objectives:

- Determine budget allocations for road maintenance and improvement
- Prepare for work programmes
- Determine long term network performance
- Assess impact on road users

Road Network Matrix

Length of Roads (km)

Road Class	Cond.	Flexible Pavement			Gravel Pavement		
		Traffic			Traffic		
		High	Med.	Low	High	Med.	Low
Trunk	G	76	283	307	686	452	703
	F	485	762	561	855	904	1961
	P	911	420	321	1905	2432	4321
Feeder	G						
	F						
	P						
Urban	G						
	F						
	P						

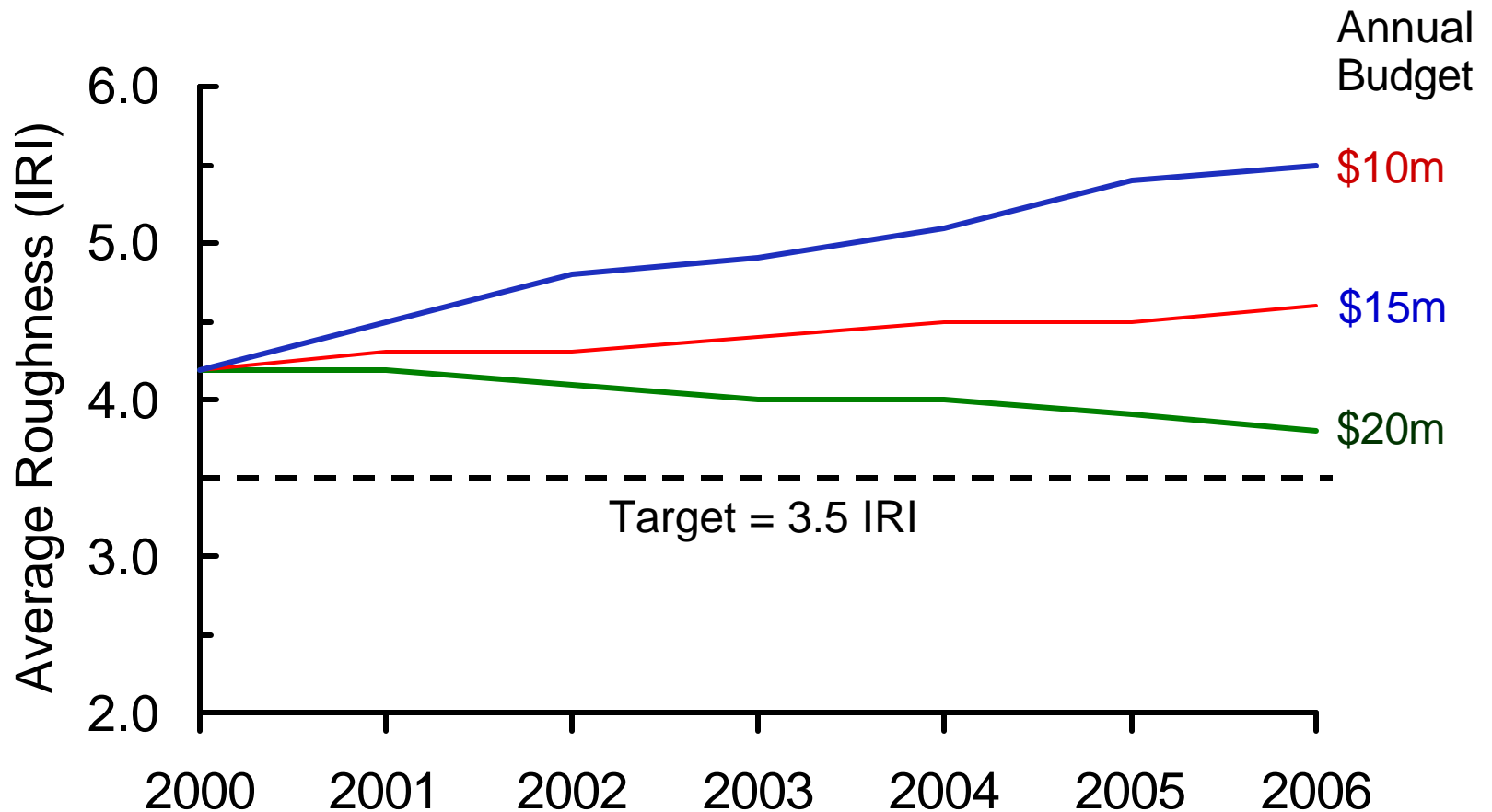
Expenditure Strategy Analysis ...

Long term budget forecasts

	1	2	3	4	5
Maintenance	128	133	135	135	136
Rehabilitation	99	77	79	83	86
Improvement	56	88	87	91	90
Development	45	78	66	36	49
Bridges	34	37	40	39	40
TOTAL	362	413	407	384	401

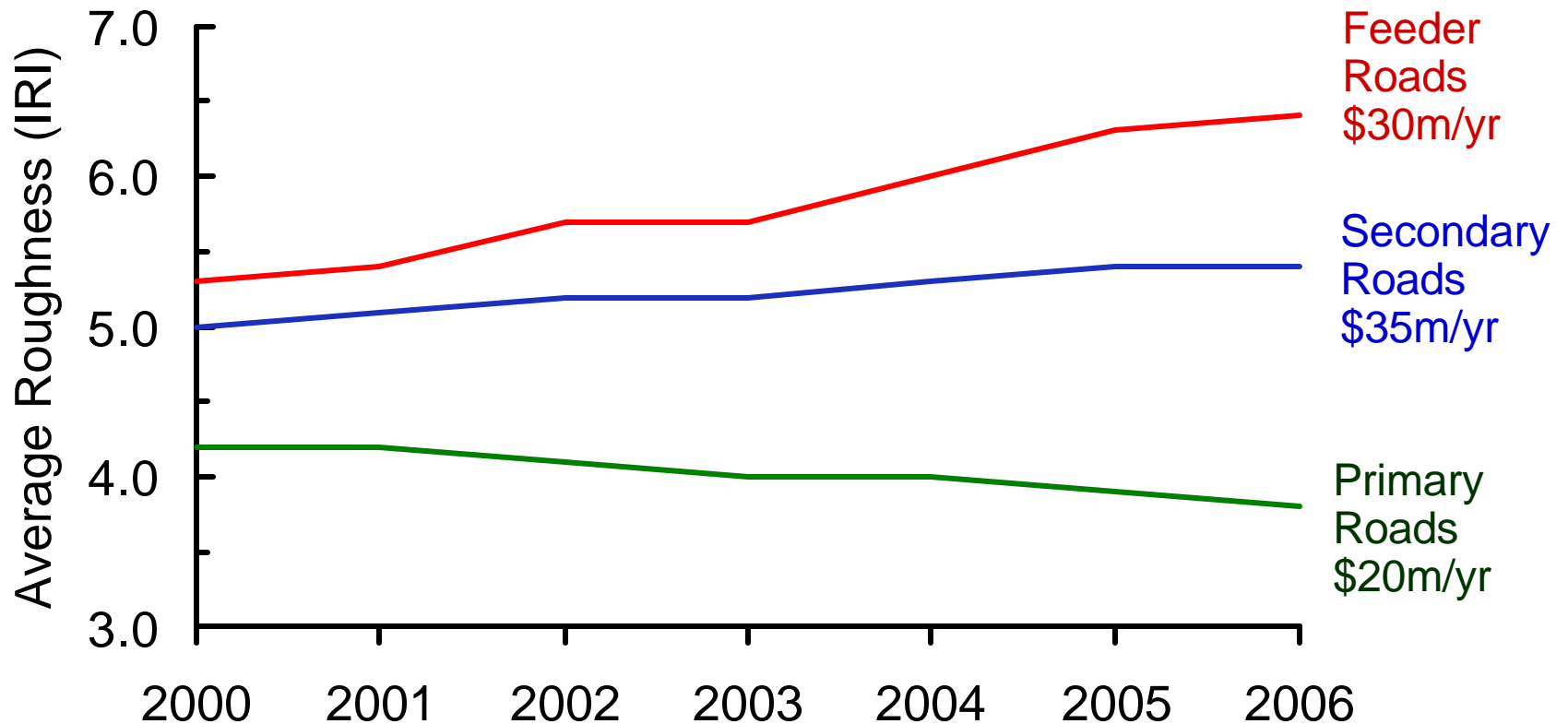
Effect of budget levels

Primary Roads

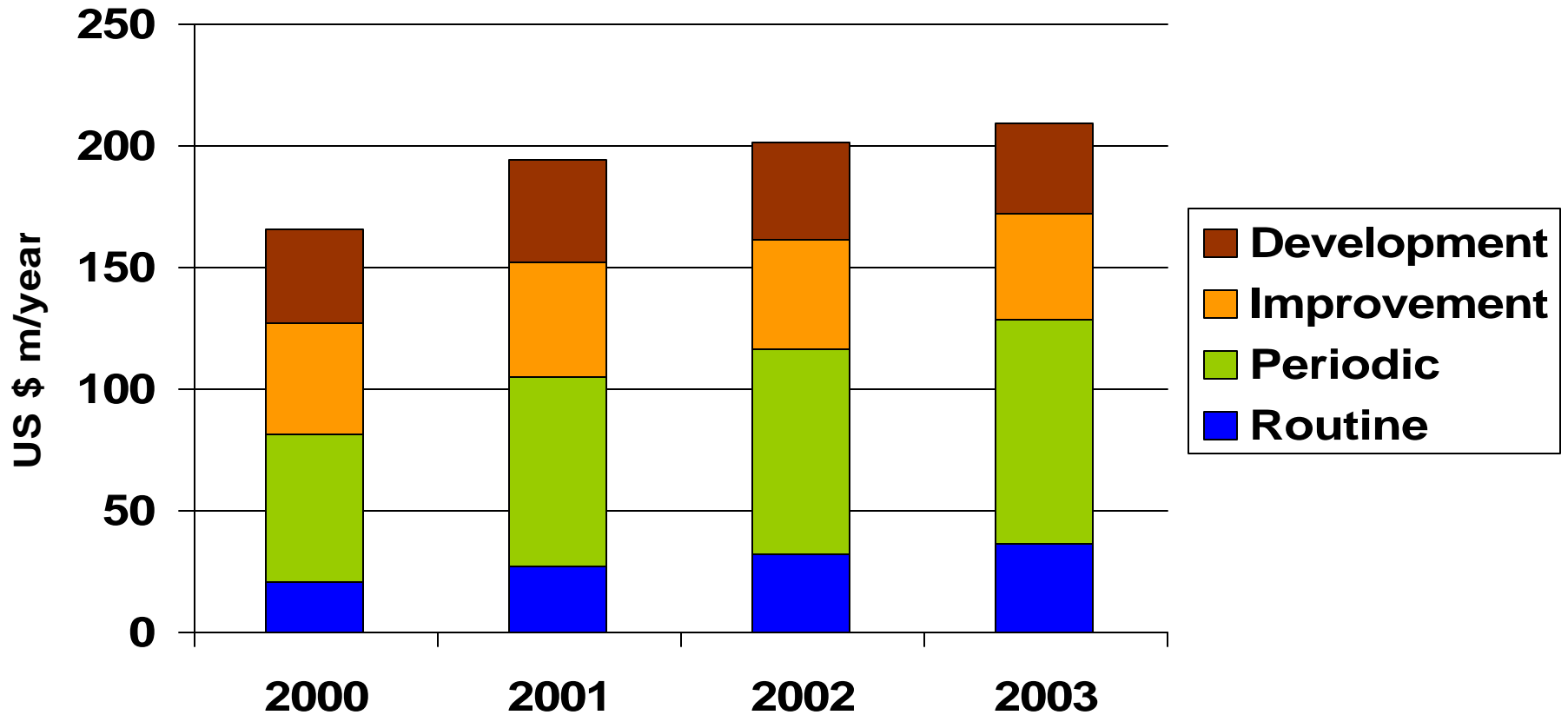


Road Network Performance

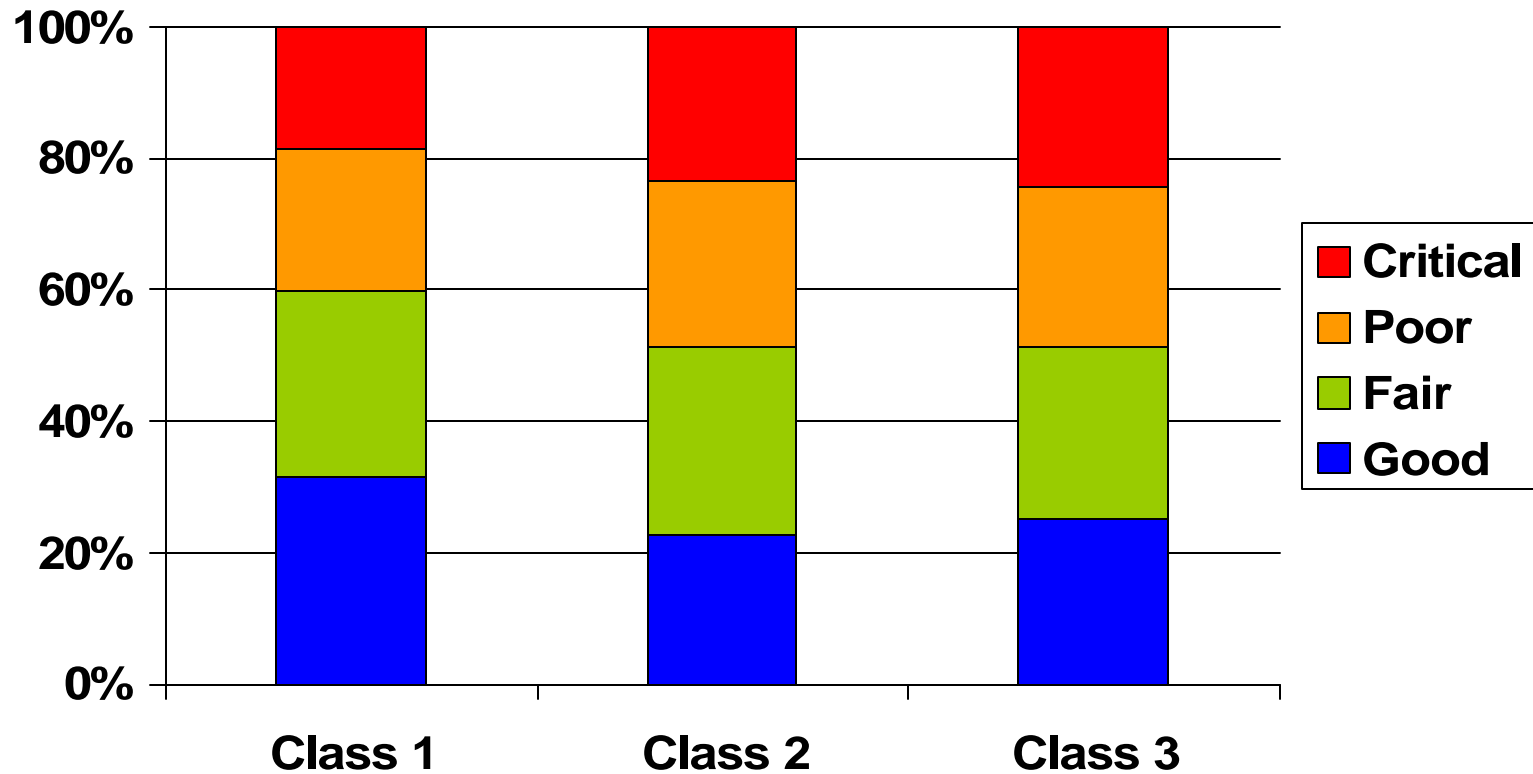
Budget Allocations



Optimal budget requirements



Pavement condition by road class (2001)



Programme Analysis

Concerned with the preparation of single or multi-year road work and expenditure programmes under specified budget constraints.

- **Objective: prioritise candidate road projects in each year within annual budget constraint**
- **Annual budgets obtained from strategic maintenance plan**

Work Program

Priority Rank	Road Section	Length (km)	Province or District	Type of Road Work	Scheduled Year	Cost \$m	Cumulative S\$m
1	N1-2	20.5	2	Resealing	2000	5.4	5.4
2	N4-7	23.5	7	Overlay 40mm	2000	10.9	16.3
3	N2-5	12.5	5	Reconstruct	2000	8.6	24.9
4	R312-1	30	4	Widen 4 lane	2000	31.4	56.3
5	R458-3	36.2	3	Overlay 60mm	2000	16.3	72.6
:	:	:	:	:	:	:	:
1	N4-16	32.1	6	Reconstruct	2001	22.8	22.8
2	R13-23	22.4	4	Overlay 40mm	2001	9.7	32.5
3	N521-5	45.2	2	Widen 4 lane	2001	41.3	73.8
:	:	:	:	:	:	:	:
1	N1-6	30.2	4	Resealing	2002	8.2	8.2
2	N7-9	17.8	3	Overlay 60mm	2002	9.2	17.4
3	F2140-8	56.1	1	Reconstruct	2002	34.9	52.3
:	:	:	:	:	:	:	:

Project Appraisal

Project types

- New construction, upgrading
- Reconstruction, resealing
- Widening, lane addition
- Non-Motorised Transport lanes

Calculated economic indicators

- Net Present Value (NPV)
- Economic Rate of Return (ERR)
- Benefit Cost Ratio (BCR)
- First Year Rate of Return (FYRR)

Project Level Outputs

- **Sensitivity analysis results**
 - **Scenario analysis**
 - **Road condition indicators**
 - **Road user cost details**
 - **Energy & emissions**



Association
mondiale
de la Route



World Road
Association

Multi Criteria Analysis

Multi Criteria Analysis

- **Method: Analytic Hierarchy Process (AHP)**
- **Criteria – defined/selected by the user**
- **Relative weights: user-defined for the criteria selected**
- **Determine the Performance indices for each road investment alternative**
- **Calculate ranking vectors (or scores) for the investment alternatives**

Criteria Considered

- **Economic**
 - Road Agency Cost
 - Road User Cost
 - Net Present Value
- **Safety**
- **Environmental**
- **Delay due to congestion (VCR)**
- **Comfort (riding quality)**
- **Energy use**
- **Social concerns (can be disaggregated at the micro level analysis)**
- **Political concerns**

Social/Political Concerns

Rating of the net effect of each alternatives (PI)

1 Major dissatisfaction

2 Minor dissatisfaction

3 Indifference

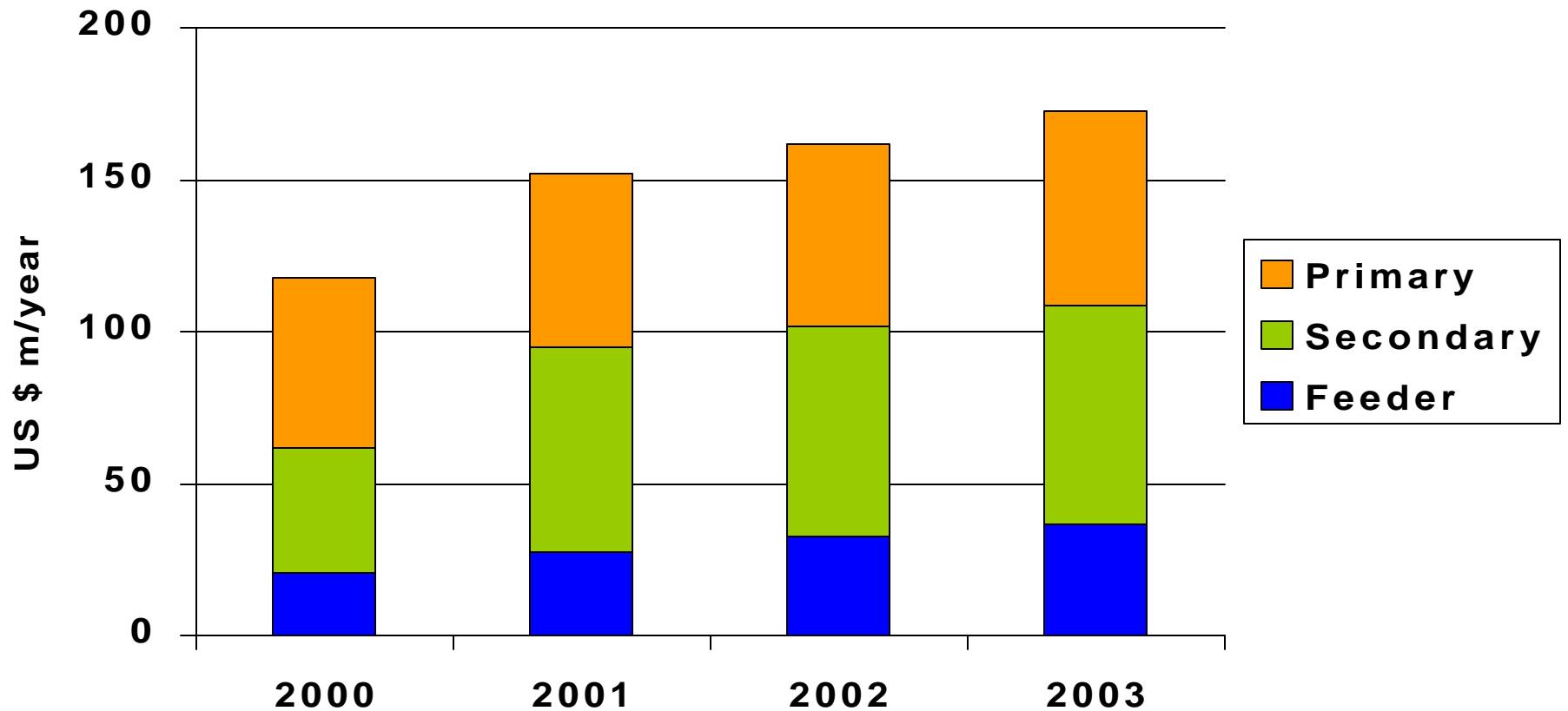
4 Minor satisfaction

5 Major satisfaction

Application Levels

- **Strategic planning – using the scores to:**
 - Determine total needs for different road categories (primary, secondary, feeder, urban)
 - Allocate budget between road classes
 - Allocate budget between regions
 - Allocate budget between works types
- **Work programming – prepare multi year work programmes under budget constraints using the ranking vectors calculated**
- **Project analysis – for each road section select investment alternatives with the highest score**

Optimal budget allocations



Work Program

Priority Rank	Road Section	Length (km)	Province or District	2000		2001		2002		2003	
				Road Work	Cost \$m	Road Work	Cost \$m	Road Work	Cost \$m	Road Work	Cost \$m
1	N1-2	20.5	2	RESEAL	5.4	R.M.	0.185	R.M.	0.185	R.M.	0.185
2	N4-7	23.5	7	OVL40MM	10.9	R.M.	0.212	R.M.	0.212	R.M.	0.212
3	N2-5	12.5	5	RECON	8.6	R.M.	0.113	R.M.	0.113	R.M.	0.113
4	R312-1	30	4	WIDEN-4	31.4	R.M.	0.180	R.M.	0.180	R.M.	0.180
5	R458-3	36.2	3	OVL60MM	16.3	R.M.	0.217	R.M.	0.217	R.M.	0.217
:	:	:	:	:	:	:	:	:	:	:	:
16	N4-16	32.1	6	R.M.	0.289	RECON	22.8	R.M.	0.289	R.M.	0.289
17	R13-23	22.4	4	R.M.	0.134	OVL40MM	9.7	R.M.	0.134	R.M.	0.134
18	N521-5	45.2	2	R.M.	0.407	WIDEN-4	41.3	R.M.	0.407	R.M.	0.407
:	:	:	:	:	:	:	:	:	:	:	:
28	N1-6	30.2	4	R.M.	0.272	R.M.	0.272	RESEAL	8.2	R.M.	0.272
29	N7-9	17.8	3	INLAY	0.240	R.M.	0.200	OVL60MM	9.2	R.M.	0.160
30	F2140-8	56.1	1	PATCH	0.202	R.M.	0.202	RECON	34.9	R.M.	0.168

Note: RM = Routine Maintenance



Association
mondiale
de la Route



World Road
Association

Implementation

Some Country Experience

- Russia
- Bangladesh
- Armenia
- Estonia
- Slovenia
- Papua New Guinea
- Thailand
- Brazil
- Tanzania
- Zimbabwe
- Australia
- New Zealand
- Sweden (benchmark)
- South Africa
- Finland
- Fiji
- Namibia
- Ukraine
- Lebanon
- Czech Republic
- Scotland
- Malaysia
- Ghana

Conclusions

- **HDM-4 is based on a well established economic analysis framework**
- **Models derived from large scale field experiments conducted world-wide**
- **International standard tool for road sector planning and management**
- **Provides a common framework for analysis of road management options**
- **International technical support behind HDM-4**