SUB-SAHARAN AFRICA TRANSPORT POLICY PROGRAM

SSATP

A User Guide to Road Management Tools

A USER GUIDE TO ROAD MANAGEMENT TOOLS

Compiled by Ig Schutte

December 2008

The SSATP is an international partnership to facilitate policy development and related capacity building in the transport sector in Sub-Saharan Africa.

Sound policies lead to safe, reliable and cost-effective transport, freeing people to lift themselves out of poverty, and helping countries to compete internationally.

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ABBREVIATIONS, ACRONYMS & DATA NOTES	
AADT	Average annual daily traffic
ADT	Average daily traffic
AST	Appraisal Summary Table
AusAID	Australian Agency for International Development
BAA	Basic Access Approach
BMS	Bridge Management System
BSC	Balanced Scorecard
CCRI	Central Road Research Institute
CDB	Central Database
CSIR	Council for Scientific and Industrial Research
DEFINITE	DEcisions on a FINITE set of alternatives
ESA	Equivalent standard axle
GIS	Geographic Information System
GPS	Global Positioning System
GTZ	German Agency for Technical Cooperation
HCM	Highway Cost Model
HDM	Highway Development and Management model
ILO	International Labour Organization
IMT	Intermediate mean of transport
IRAP	Integrated Rural Accessibility Planning
IRDP	Integrated Rural Development Project
IRI	Investment rate of interest
IT	Information Technology
km	Kilometer
LCPC	*Laboratoire Central des Ponts et Chaussées*
LFA	Logical Framework Analysis
LFM	Logical Framework Matrix
MIT	Massachusetts Institute of Technology
MMS	Maintenance Management System
NATA	New Approach to Transport Appraisal

ABBREVIATIONS, ACRONYMS & DATA NOTES	
PAM	Performance Assessment Model
PRA	Participatory Rural Appraisal
RED	Roads Economic Decision model
RMI	Road Management Initiative
RMS	Road management system
RONET	Road Network Evaluation Tools
RRD	Rural road database
RRN	Rural road network
RTI	Rural Transport Infrastructure
RTIM	Road Transport Investment Model
RUC	Road User Charges model
RUCKS	Road User Costs Knowledge System
SLA	Sustainable Livelihood Approach
SOURCE	Standard Overall Ultralite Road Care Estimate
SRMC	Short-run marginal cost
SSATP	Sub-Saharan Africa Transport Policy Program
TRL	Transport Research Laboratory
TRRL	Transport and Road Research Laboratory
TSS	Traffic sub-system
UK	United Kingdom
UNDP	United Nations Development Programme
US$	American Dollar
USAID	United States Agency for International Development
VDC	Village Development Committee
veh	Vehicle
VOC	Vehicle operating cost
VPD	Vehicle per day
yr	Year

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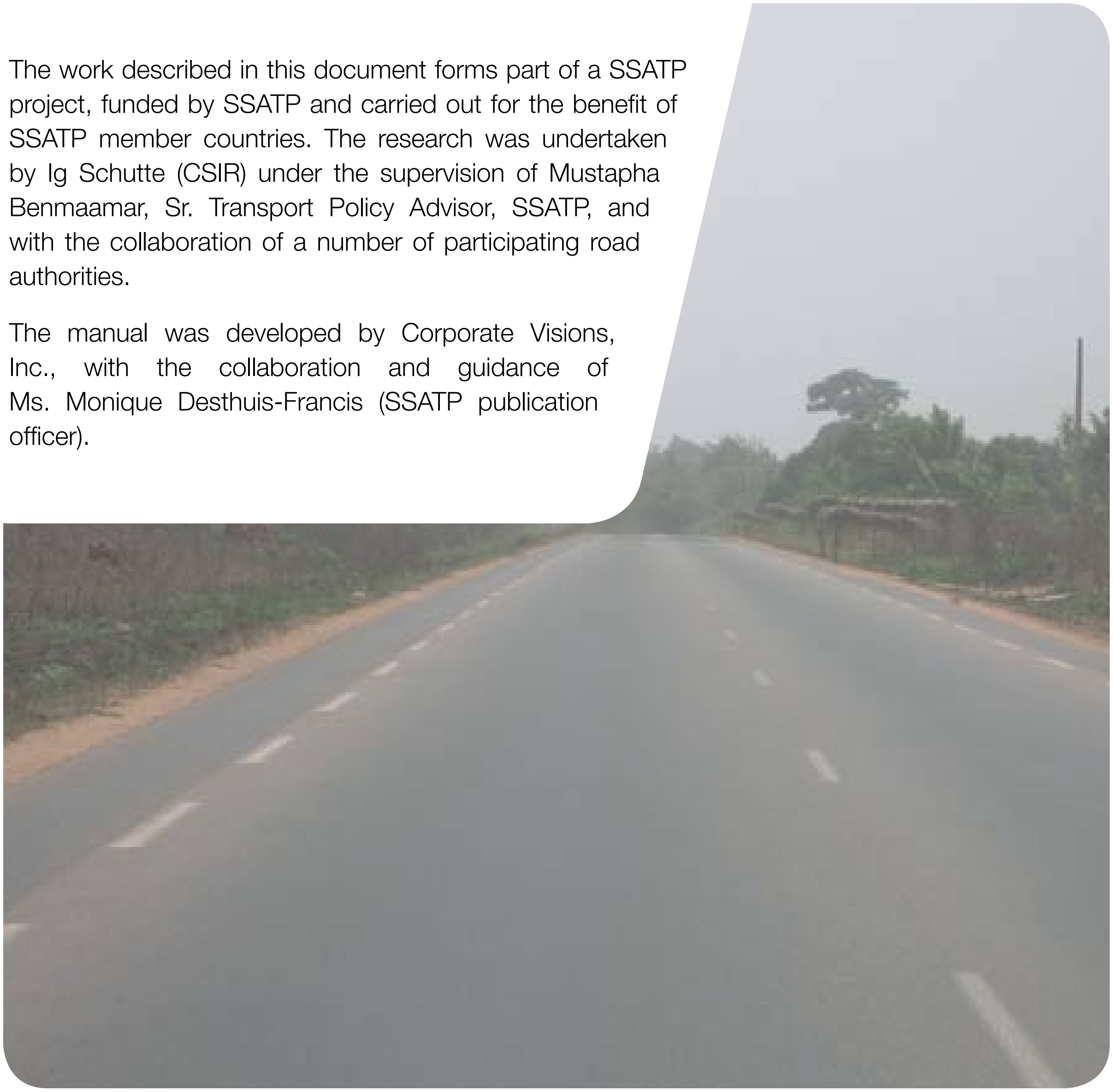
The manual was developed by Corporate Visions, Inc., with the collaboration and guidance of Ms. Monique Desthuis-Francis (SSATP publication officer).



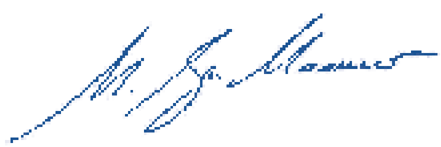
Preface

Appropriate use of road management systems to make informed decisions and prepare sound road maintenance programs is one of the performance indicators used to assess the efficiency of road administrations and agencies. SSATP management shares the view of the member countries that these tools are inadequately, insufficiently applied and have less than their potential impact on improved road networks.

When appraising various transport infrastructure projects ranging from the rural transport infrastructure (e.g. village paths), performing mainly a social function, to the national road network, performing mainly an economic function, there is a need to use appropriate methods and approaches which are often incorporated in many available road management tools.

This road management tools guide gives an overview of 14 selected tools for road infrastructure management, and explains how they can assist road administrations and contribute to improving road management practices. This manual captures, in a single document, important features of these tools, scattered around in various documents and on various websites. By providing easy access to basic information for each of the tools, the document intends to promote their use in the SSATP member countries (and key partners groups within).

This road management tools guide is aimed at decision-makers in road administrations who may not always have the necessary technical background or time for in-depth study, but for whom a basic understanding of these tools may be desirable, if not essential. This guide is also intended as an introduction to first-time readers at the technical level. For these readers, this document provides sufficient information and the necessary context to guide them in selecting appropriate tools. It also strives to “wet their appetite” for a more in-depth study of these tools, which is a prerequisite for their application to real-life situations.



Mustapha Benmaamar
Sr. Transport Policy Advisor, SSATP

1. Introduction

1.1. PURPOSE OF THE USER GUIDE AND TARGET AUDIENCE

This user guide gives an overview of selected tools for road infrastructure management, and explains how they can assist road authorities and contribute to road management. It captures, in a single document, important features of these tools, scattered around in various documents and on various websites. By providing easy access to basic information on these tools, the document intends to promote their use in the region.

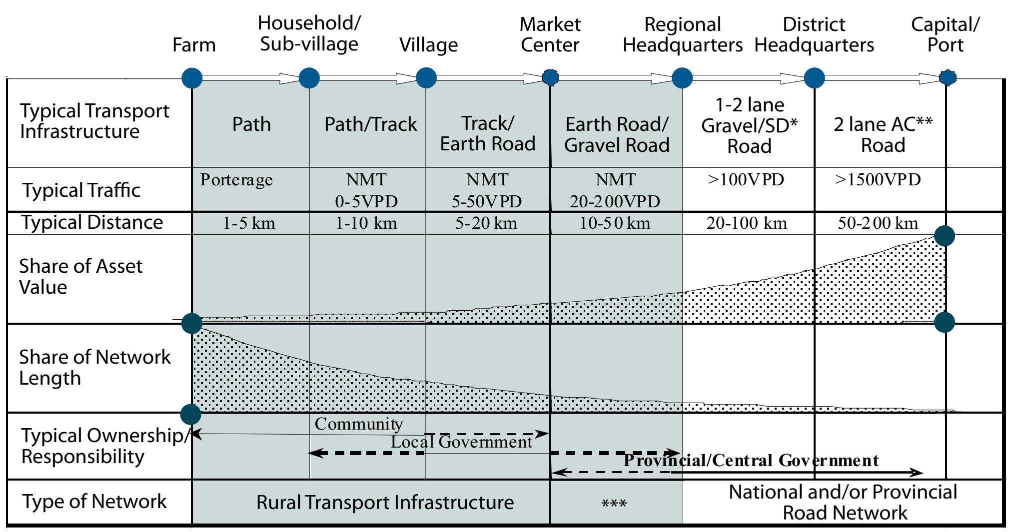
This overview document is aimed at politicians and high-level decision makers in road authorities and road agencies who may not always have the necessary technical background or time for in-depth study, but for whom a basic understanding of these tools may be desirable, if not essential. The manual is also intended as an introduction to first-time readers at the technical level. For these readers, this document provides sufficient information and the necessary context to guide them in selecting appropriate tools. It also strives to “wet their appetite” for a more in-depth study of these tools, which is a prerequisite for their application to real-life situations.

1.2. SCOPE OF THE DOCUMENT

1.2.1 Type of road

In terms of *type of road*, this document covers the whole spectrum of non-urban roads: from the rural road network, performing mainly a social function, to the national road network, performing mainly an economic function. Important features of these types of road are shown in the figure below.

FEATURES OF RURAL (SOCIAL) AND NATIONAL (ECONOMIC) ROADS



* Surface
** Asphalt Concrete
*** Part of either RTI or the Provincial Network

1.2.2 Tools

In terms of *tools*, this document gives an overview of Road Management Systems (RMSs), as well as a selected number of other tools available for road infrastructure management. These “other tools” are listed alphabetically in the table below. Most of these tools are supported by the SSATP. Some “new” tools have been added as they too can assist road authorities in managing road infrastructure.

OTHER TOOLS (I.E. TOOLS IN ADDITION TO RMS) INCLUDED IN THIS DOCUMENT	
BAA	Basic Access Approach
BSC	Balanced Scorecard
DEFINITE	DEcisions on a FINITE set of alternatives
HDM	Highway Development and Management model
IRAP	Integrated Rural Accessibility Planning
LFA	Logical Framework Analysis
NATA	New Approach to Transport Appraisal
PAM	Performance Assessment Model
PRA	Participatory Rural Appraisal
RED	Roads Economic Decision model
RONET	Road Network Evaluation Tools
RUC	Road User Charges model
SLA	Sustainable Livelihood Approach
SOURCE	Standard Overall Ultralite Road Care Estimate

In addition to the tools listed above, the following tools are also discussed briefly:

- **Road Mentor**
- **dTIMS**
- **RTIM3**
- **SuperSurf**
- **Struman Bridge Management System**

1.3. STRUCTURE OF THE DOCUMENT

Following this introduction, key concepts and the general approach adopted here are explained in Chapter 2. This is done to set the scene for the discussion of selected tools for road infrastructure management in subsequent chapters. Road management systems are discussed first (in Chapter 3), as it constitutes the basic tool for managing road infrastructure. A selected number of “other tools”, i.e. tools that could be used in addition to the RMS, are discussed in alphabetical order Chapters 4 to 17. A number of additional tools are presented briefly in Chapter 18. Chapter 19 contains summaries of the tools, as well as concluding remarks.

2. Key Concepts and General Approach

2.1. INTRODUCTION

In order to set the scene for an overview of selected tools for road infrastructure management, this chapter focuses on the scope and objective of road management. Given the nature and scope of tools for this purpose, and the different options for classifying them, this chapter then explains the classification system adopted in this document. Finally, it explains how these tools can contribute to different road management functions.

2.2. SCOPE AND OBJECTIVE OF ROAD MANAGEMENT

In Overseas Road Note 15, "road management" is defined as "(the) process of maintaining and improving the existing road network to enable its continued use by traffic efficiently and safely, normally in a manner that is effective and environmentally sensitive; a process that is attempting to optimize the overall performance of the road network over time" (TRL, p. 66).

Regarding the point of departure in road management, the following view is adopted: "Road management starts from the premise that the road network is an asset which needs to be maintained and improved so as to secure the best performance and value-for-money and the maximum service life" (TRL, p. 5). The aims of road management are defined as follows: "The aims of road management are to enable the network to withstand the damage caused by wear and tear, to prevent substandard conditions from developing, and to ensure that traffic can continue to travel, in a manner which is safe, efficient, reliable and which causes the least damage to the environment" (TRL, p. 5).

Road management involves four management functions, planning, programming, preparation and operations (Kerali, pp. 5-6). These functions, as well as other aspects of road management, including the road management system (RMS), are discussed further in the next chapter.

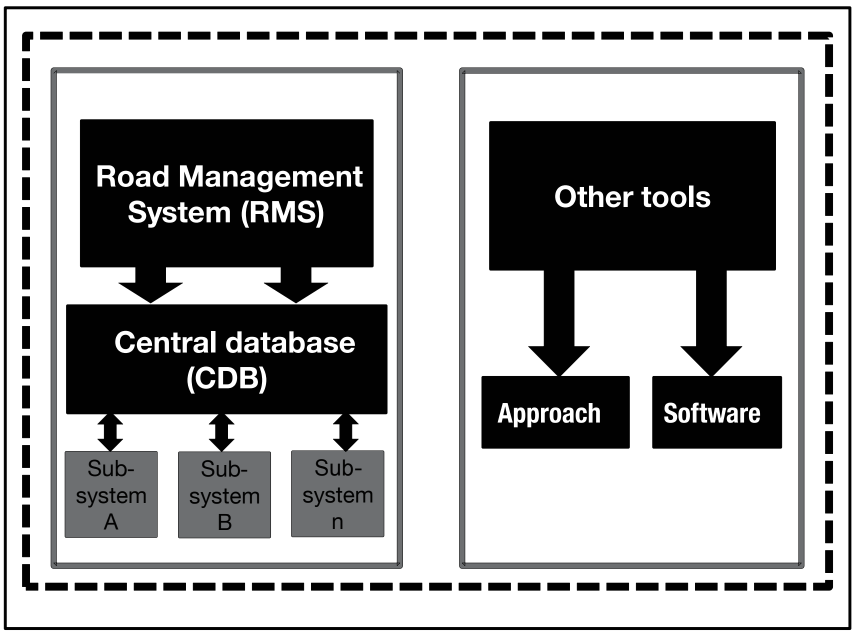
2.3. CLASSIFYING TOOLS FOR ROAD INFRASTRUCTURE MANAGEMENT

As shown in the next chapter of this document, it is clear that the RMS is indispensable for road infrastructure management and that it constitutes the main tool for doing this. There are, nonetheless, a number of other tools that were developed to address specific aspects of road management. As such, they can play an important role in supplementing or supporting the RMS. Their interface with the RMS could be either direct or indirect – when this interface is direct, data obtained from the RMS would be used directly in/by the tool. The HDM-4 model which, inter alia, can be used to determine the economic feasibility of investment options at the project level, and thus to prioritize investment options in terms of their economic attractiveness, is one example of a tool that addresses a particular challenge in the road infrastructure management domain.

In classifying these tools (i.e. the RMS together with "other tools"), different viewpoints can be adopted. On the one hand, a RMS could be viewed as the sum of all tools discussed here (as well as all other available tools not discussed). In that sense, all available tools would constitute elements of a comprehensive RMS. On the other hand, the RMS could be approached differently: the "narrow" approach views the RMS in the traditional (narrow) sense of the word, as described in the next chapter. With that perspective, these "other tools" would not form part of an RMS.

In this document, this latter (narrow) approach is adopted. Regarding tools for road infrastructure management, a distinction is therefore made between the *RMS* (as defined by Kerali and others; see the next chapter), and "*other tools*", such as HDM-4. This perspective is reflected diagrammatically in the figure below. In the case of the RMS, the CDB (central database) constitutes the interface between a number of systems such as the PMS (pavement management system) and the MMS (maintenance management system).

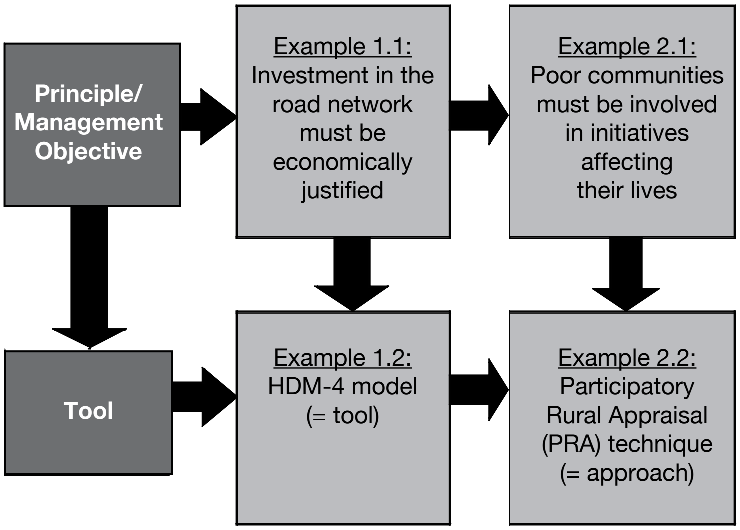
CLASSIFICATION OF TOOLS FOR ROAD INFRASTRUCTURE MANAGEMENT



As shown in the figure above, "other tools" can be classified as either an approach or a software. In this document, an approach (technique) is defined as a sequence of steps that needs to be undertaken in order to ensure that a given principle is adhered to or a given objective is reached, e.g. "scarce economic resources must by optimally allocated". A "software" is viewed as an approach (as defined above) that has been computerized, such as HDM-4. From the discussion in the remaining chapters, it is clear that computerization in fact is not possible, necessary or desirable for all tools.

The figure below provides examples of how tools can be used in the case of accepted principles (management objectives). In this document, a principle (management objective) is defined as a non-negotiable directive affecting the activities and decisions of the road authority, bearing in mind that the road authority constitutes the agent of the community it serves and that it should act in the best interest of that community.

LINKAGE BETWEEN MANAGEMENT PRINCIPLES/OBJECTIVES AND TOOLS



2.4. CONTRIBUTION OF TOOLS TO ROAD MANAGEMENT FUNCTIONS

The table below shows how different tools can contribute to the different functions of road infrastructure management. These functions are the following:

- **Road Sector Policy Formulation: Defining appropriate standards and policies**
- **Road Network Monitoring: Knowing network extent, condition and traffic**
- **Network Needs Assessment: Planning and allocating road network expenditures**
- **Programming Road Expenditures: Appraising and ranking of investment options**
- **Preparation of Road Projects: Packaging projects for implementation**
- **Monitoring Road Agency Operations: Scheduling and monitoring road works**
- **Monitoring Road Agency Performance: Informing performance measures**

In this table, tools indicated in **bold** have a particular focus on rural (social) roads, as defined in Chapter 1.2.1 of this document. The short names of tools are used – the reader is referred to Chapter 1.2.2 for the full name.

CONTRIBUTION OF TOOLS TO ROAD MANAGEMENT FUNCTIONS						
Road sector policies formulation	Road network monitoring	Network needs assessment	Programming road expenditures	Preparation of road projects	Monitoring road agency operations	Monitoring road agency performance
RMS	RMS	RMS	RMS	RMS	RMS	RMS
	BAA	**BAA**	**BAA**			
	IRAP	**IRAP**	**IRAP**			
		PRA	**PRA**			
		SLA				
		LFA				
HDM-4		HDM-4	HDM-4	HDM-4		
RED		RED	RED	RED		
PAM		PAM				
RUC		RUC				
RONET		RONET	RONET	RONET		
		NATA	NATA			
		DEFINITE	DEFINITE			
	SOURCE					
						BSC

3. RMS: Road Management Systems

3.1. INTRODUCTION

This chapter focuses on the road management system (RMS), which constitutes the main tool for managing the road infrastructure, and on the functions inherent in road infrastructure management, planning, programming, preparation and operations. It describes the management cycle and discusses typical components of the RMS. Finally, it considers success factors for a RMS.

3.2. RMS DEFINED

A "road management system" is defined as a computer-based system used to assist with road management (TRL, p. 66). In a more recent World Bank publication, a road management system is defined as follows:

WORLD BANK DEFINITION OF ROAD MANAGEMENT SYSTEM
(MCPHERSON AND BENNETT, P. 3)

A RMS (road management system) is defined here as any system that is used to store and process road and/or bridge inventory, condition, traffic and related data, for highway planning and programming. Associated with the RMS are appropriate business processes to use the RMS to execute the business needs of the highway agency.

3.3. MANAGEMENT FUNCTIONS

In road management, a distinction is made between four management functions, namely planning, programming, preparation and operations. These functions are defined in the boxes below.

PLANNING
(KERALI, PP. 5-6)

Planning involves the analysis of the road system as a whole, typically requiring the preparation of medium to long term, or strategic, estimates of expenditure for road development and preservation under various budget and economic scenarios. Predictions may be made of road network conditions under a variety of funding levels in terms of key indicators together with forecasts of required expenditure under defined budget heads. The physical highway system is usually characterized at the planning stage by:

Characteristics of the road network:

Grouped in various categories and defined by parameters such as:

- Load class or hierarchy
- Traffic flow/loading/congestion

- Pavement types
- Pavement condition

Length of road in each category

Characteristics of the vehicle fleet which use the road network

The results of the planning exercise are of most interest to senior policy makers in the roads sector, both political and professional. A planning unit will often undertake this work.

PROGRAMMING
(KERALI, PP. 5-6)

Programming involves the preparation, under budget constraints, of multi-year road work and expenditure programs in which sections of the network likely to require maintenance, improvement or new construction, are selected and analyzed. It is a tactical planning exercise. Ideally, cost-benefit analysis should be undertaken to determine the economic feasibility of each set of works. The physical road network is considered at the programming stage on a link-by-link basis, with each link characterized by homogeneous pavement sections defined in terms of physical attributes. The programming activity produces estimates of expenditure in each year, under defined budget heads, for different types of roadwork and for each road section. Budgets are typically constrained, and a key aspect of programming is to prioritize the road works in order to find the best use of the constrained budget. Typical applications are the preparation of a budget for an annual or a rolling multi-year work program for a road network, or sub-network. Managerial-level professionals within a road organization normally undertake programming activities, perhaps within a planning or a maintenance department.

PREPARATION
(KERALI, PP. 5-6)

This is the short-term planning stage where road schemes are packaged for implementation. At this stage, designs are refined and prepared in more detail; bills of quantities and detailed costing are made, together with work instructions and contracts. Detailed specifications and costing are likely to be drawn up, and detailed cost-benefit analysis may be carried out to confirm the feasibility of the final scheme. Works on adjacent road sections may be combined into packages of a size that is cost-effective for execution. Typical preparation activities are the detailed design of:

- An overlay scheme
- Road improvement works (for example, construction along a new alignment, road widening, pavement reconstruction, etc.)

For these activities, budgets will normally already have been approved. Preparation activities are normally undertaken by middle to junior professional staff and technicians within a design or implementation department of a road organization, and by contracts and procurement staff.

OPERATIONS
(KERALI, PP. 5-6)

These activities cover the on-going operation of an organization. Decisions about the management of operations are made typically on a daily or weekly basis, including the scheduling of work to be carried out, monitoring in terms of labor, equipment and materials, the recording of work completed, and use of this information for monitoring and control. Activities are normally focused on individual sections or sub-sections of a road, with measurements often being made at a relatively detailed level. Operations are normally managed by sub-professional staff, including works supervisors, technicians, clerks of works, and others.

As one moves from planning to operations, there is a constant change of emphasis in terms of aspects such as focus of attention and time horizon, as explained below:

- **The focus of attention is transferred from the network as a whole to the specific locations where works are being undertaken.**
- **The time horizon narrows from a span of several years to the individual budget year and then down to the current week or day.**
- **The level of management responsibility decreases.**
- **The information required for each function changes in scope from summary or sampled data about the entire network to detailed and precise data about specific road sections.**
- **Where computer systems are used to support management activities, automated processes which produce standard reports on a pre-defined basis are progressively replaced by processes in which managers work interactively with the computer.**
- **There is a transition from tasks which are conventionally viewed as client function to tasks which are increasingly amenable to being contracted out.**

This “change of emphasis” is also shown in the table below, where the different management functions are described in terms of management aims, network coverage, time horizon and management staff concerned.

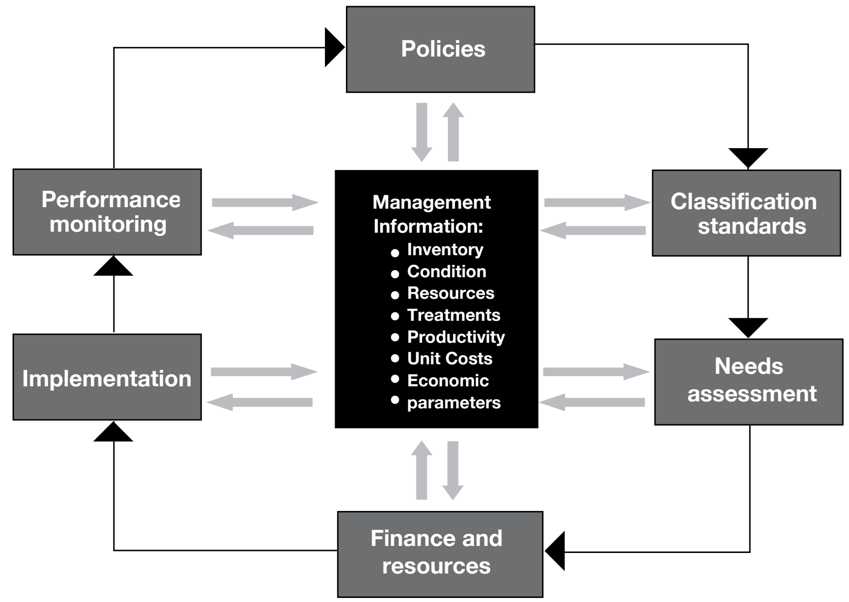
SCOPE OF ROAD MANAGEMENT FUNCTIONS				
Management function	Nature and scope of actions involved	Network coverage	Time horizon	Management staff concerned
Planning	• Defining road standards which optimize the use of resources • Determining the budget required to support defined standards	Entire network	Long term (strategic)	Senior managers and policy-makers
Programming	Determining the work program that can be undertaken within the budgetary period	Sections likely to need treatment	Medium term (tactical)	Managers and budget holders
Preparation	• Design of works • Preparation and issue of contract or work instruction	Contract or work packages	Budget year	Engineers, technical and contracts staff
Operations	Undertaking tasks as part of works activity	Sub-sections where works are taking place	On-going	Works supervisors

Source: TRL, p. 6

3.4. THE MANAGEMENT CYCLE

“The highway management process as a whole can, therefore, be considered as a cycle of activities undertaken within each of the management functions of Planning, Programming, Preparation and Operations” (Kerali, p. 8). The sequence of steps constituting the management cycle is indicated in the diagram below. This diagram also indicates the importance of management information and the linkage of each step in the cycle to the “management information” database.

THE MANAGEMENT CYCLE



Source: Robinson et al, 1998.

3.5. COMPONENTS OF THE ROAD MANAGEMENT SYSTEM

The table below shows examples of different subsystems available for use in road management systems.

TYPICAL COMPONENTS OF THE ROAD MANAGEMENT SYSTEM

Related management function	System description
Planning	• Strategic analysis system • Network planning system • Pavement management system
Programming	• Program analysis system • Pavement management system • Budgeting system
Preparation	• Project analysis system • Pavement management system • Bridge management system • Pavement/overlay design system • Contract procurement system
Operations	• Project management system • Maintenance management system • Equipment management system • Financial management/accounting system

The box below contains definitions of some of the systems listed above, as provided by Pinard for Botswana and documented by Heggie (p. 111).

ROAD MANAGEMENT SYSTEM (RMS):
CENTRAL DATABASE AND SUBSYSTEMS

The RMS consists of a central database linked to subsystems covering data collection, planning, and management. The role of each subsystem is summarized below.

(1) *Central database (CDB)* contains validated summary data generated by the other subsystems. To allow rapid export and import of data to and from the other subsystems, the CDB and all subsystems must use the same database management system (e.g. a Fourth Language database management system).

(2) *Pavement management subsystem (PMS)* determines the type, as well as optimum timing and level of maintenance required, given prevailing road conditions. It provides information on: (i) optimum maintenance requirements, (ii) the short and long term consequences of restricted maintenance funding, (iii) pavements with the highest priority when maintenance funds are limited, (iv) the best maintenance strategy for each road link, and (v) the impact of past maintenance strategies on overall road conditions.

- At the *network level*, the PMS identifies and ranks pavements for improvement, prepares network level budgets, produces long-range budget forecasts, assesses network level pavement conditions, and forecasts future pavement conditions.
- At the *project level*, the PMS assesses causes of road deterioration, specifies alternative pavement interventions, assesses the benefits of alternative pavement interventions using life cycle costing, and selects and displays preferred solutions.

The support system for the PMS includes data collection, data analysis (using HDM-4), optimization (using appropriate criteria), and preparation of an implementation program.

(3) *Maintenance management subsystem (MMS)* specifies, for the selected maintenance strategy: (i) performance standards describing the procedures to be followed, resources required (in terms of people, equipment, and materials), and rate of production to be achieved, (ii) budget requirements (in terms of people, equipment, and materials) to accomplish the planned maintenance program, (iii) schedule of activities within the program to ensure resources are used efficiently, and (iv) a management information reporting system to provide the basis for regular management reports. The MMS will eventually include a road inventory, inspection reports, assessment of maintenance needs, costs of proposed works, priorities, implementation plans, and arrangements for monitoring results. It will help to improve the planning and scheduling

of work, establish standards (optimum standards being set by the PMS), guide management decisions (optimum timing also being determined by the PMS), and support preparation of accurate budgets.

(4) *Bridge management subsystem (BMS)* provides a rational basis for managing maintenance of bridges: (i) the identification of bridges requiring remedial action, (ii) the selection and prioritization of selected bridge works, (iii) the identification and prioritization of urgent remedial works, (iv) the identification of the best bridge maintenance strategies, and (v) the monitoring and evaluation of bridge conditions on an ongoing basis.

(5) *Traffic subsystem (TSS)* provides a variety of statistics on the road network, including traffic volume and loading by vehicle type by road link, total distance travelled, and growth rate by vehicle type by road link.

(6) *Cost accounting subsystem (CASE)* provides accurate cost accounting data for purposes of: (i) establishing budgets and standard costs for road maintenance operations, (ii) tracking and accounting for actual costs of operations by activity and cost center, and (iii) monitoring performance and assessing productivity by cost center.

(7) *Geographic information subsystem (GIS)* allows visual presentation and production of maps of the road network. The subsystem can be configured to display and plot data for any link in the road network, such as road classification, average road condition, and traffic flows.

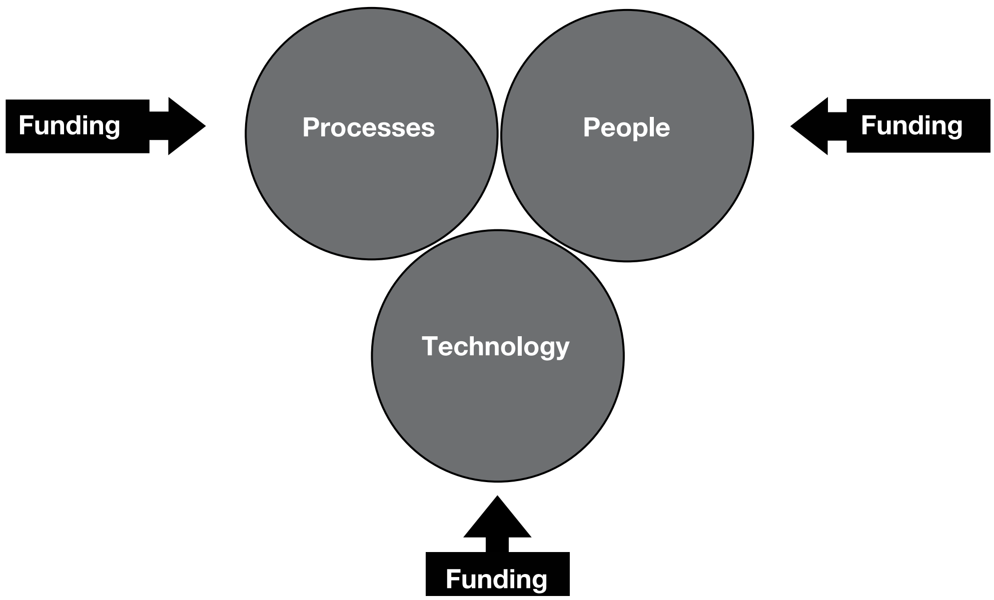
Resource requirements are: (i) two to three full-time traffic census teams, (ii) two road inspection teams (a technician and surveyor), and (iii) two engineers, a systems analyst, and a technician to operate the RMS.

3.6. SUCCESS FACTORS FOR ROAD MANAGEMENT SYSTEMS

A recent World Bank study (McPherson and Bennett, 2005) focused on success factors for road management systems. Interviews were conducted in 21 different road agencies in 16 countries (using a standard questionnaire), in order to determine their experiences in implementing road management systems. The study revealed that the successful implementation of a computerized road management system relies on three fundamental components, namely *processes, people* and *technology*. Linked to these components is *sufficient funding* (see the figure below). Underpinning these components, however, is an *"asset management mindset"* within those agencies that were successful in implementing and operating a road management system. As a result, these agencies "… explicitly and conscientiously implement policies that are geared towards managing their highway infrastructure as an asset whose value must be maintained and improved. Their executives and management promote asset management principles in order to ensure that funding and budget are allocated to appropriate areas. They are explicitly committed to the RMS, in the sense that it is built into their processes and procedures. They ensure that sufficient budget is available for data collection, for upgrades and maintenance of the systems, and for staff training and progression"

(McPherson and Bennett, p. vii). In those cases where the agency does not have an “asset management mindset”, the general conclusion from the study is that the “… allocation of budget and funds will likely be driven by political will for new development rather than taking a holistic approach to balancing new roads against maintaining asset value” (McPherson and Bennett, p. 19).

COMPONENTS OF A COMPUTERIZED RMS



The essence of success factors identified in the study are summarized in the boxes below. Success factors are explained in more detail in Chapter 20, Success Factors for Road Management Systems.

PROCESSES:
THE ROAD MANAGEMENT SYSTEM MUST HAVE AN ACTIVE ROLE IN THE ROAD AGENCY

The RMS must be viewed as an integral component in the highway agency’s monitoring and planning process. The outputs from the RMS should be used to prepare Annual Reports as this helps ensure that the data are collected regularly and the system is applied.

PEOPLE:
THE ROAD MANAGEMENT SYSTEM MUST BE FULLY INSTITUTIONALIZED AND SUPPORTED

There must be sufficient budget allocated to operate the RMS and collect the necessary data. There must be an organizational unit established to manage, monitor and continually improve RMS implementation. This organizational unit must be appropriately staffed, have clear job responsibilities, and must have clear reporting responsibilities to upper management and executive level.

INFORMATION TECHNOLOGY:
THE IT COMPONENTS MUST BE APPROPRIATE

Information Technology (IT) is becoming increasingly complex, as the demands for sharing information between applications and users grows. Any medium to large organization should have a strong IT division and an IT strategy to ensure that the benefits of IT are realized. The RMS implementation should fit within the overall IT strategy of the agency, and should be properly supported from an IT perspective.

DATA COLLECTION:
DATA COLLECTION MUST BE APPROPRIATE AND SUSTAINABLE

Only the key data that are required in decision-making should be collected and stored in the RMS. These data should be collected at the minimum level of detail with the most appropriate data collection technology given the constraints and capabilities of the agency. Where possible, data collection should be outsourced.

There must be explicit data collection policies and procedures for the agency, in a manner understood by all involved with data collection.

There must also be strict data quality assurance procedures in place so that all system users have confidence in the data and analyses provided to them.

BAA Basic Access Approach

ROAD INFRASTRUCTURE IS A PREREQUISITE (but no guarantee) for economic growth and poverty alleviation. To maximize the positive impact of transport infrastructure in general and poverty alleviation initiatives in particular, the "right" balance between interventions in the national and the rural road network is equally important – i.e. between national connectedness and basic access. BAA adopts a holistic view in understanding mobility and accessibility needs of rural communities. It provides a means of identifying, ranking and costing projects for addressing these needs, for inclusion in the decision-making process. In doing this, BAA enables road authorities to adopt an inclusive approach in managing road infrastructure, considering both national and rural roads.

4. BAA: Basic Access Approach

4.1. BACKGROUND

The provision of basic access to resources and facilities is increasingly being regarded as a basic human right, similar to the provision of basic education and basic health. In many developing countries, it is nonetheless found that the poor condition of rural transport infrastructure (RTI) jeopardizes poverty alleviation efforts. This situation prevails despite the relative success obtained with the management and financing of main road networks due to increased involvement of governments and the international donor community in recent times. It may even be possible that, in some cases, resources are over-invested in the national road network (e.g. by upgrading roads to standards that are higher than necessary), rather than addressing more pressing needs at the lower end of the road network hierarchy. The view is thus held by some that "traditional approaches" to the provision of transport infrastructure have failed to address the issue of basic access. This also means that traditional methods for screening and ranking projects may not be suitable to RTI. Accordingly, there is a need to counter the continued (narrow) focus on high-standard improvements to the main road network and to adopt a more holistic view of needs at the community level.

4.2. DESCRIPTION

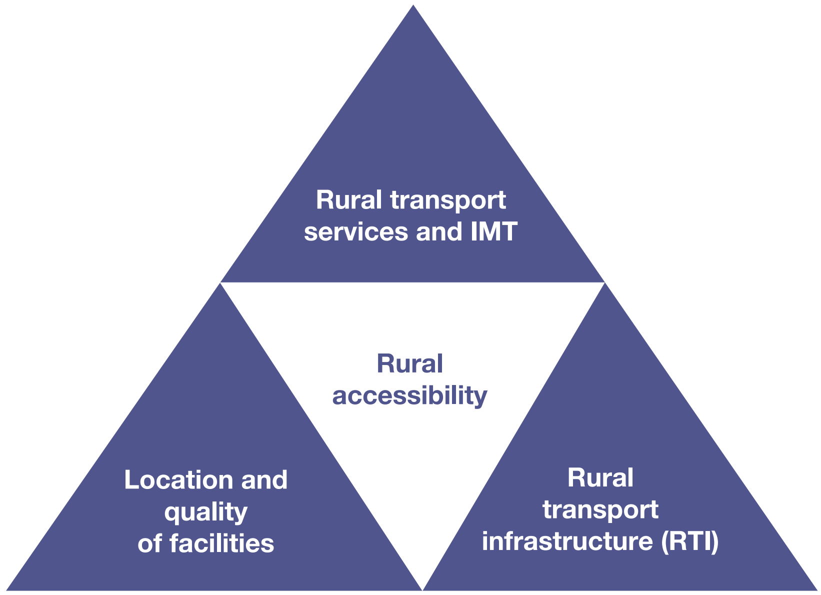
The Basic Access Approach (BAA) is an attempt to address the shortcomings of "traditional" approaches in terms of which resources are often allocated to main road networks, to the detriment of lower order networks. The BAA approach addresses the issue of basic access by giving "priority to the provision of reliable, all-season access, to as many villages as possible, over the upgrading of individual links to higher than basic access standard" (Lebo and Schelling, p. 1). An important feature of BAA is that it adopts "a more holistic understanding of the mobility and access needs of the rural communities than has traditionally been the case in rural road sub-sector investments. It is a demand-led, or people-centered, approach with an emphasis on the needs expressed by affected communities" (Lebo and Schelling, p. 6). In terms of this approach, rural transport is seen as one of several components necessary for successful rural livelihood and poverty reduction strategies. Given a focus on poverty reduction in rural areas, therefore, a comprehensive approach is required, as stated in the box below.

NEED FOR A COMPREHENSIVE APPROACH TOWARDS POVERTY REDUCTION
(LEBO AND SCHELLING, P. 6)

Poverty reduction strategies require a comprehensive framework for implementation. The simultaneous development of adequate rural infrastructure, productive sectors, social and economic services, an appropriate macroeconomic framework, and good governance and local ownership, is required for rural poverty alleviation. Effective transport, as a complementary input to nearly every aspect of rural activity, is an essential element of rural poverty reduction.

In its turn, rural transport is seen as comprising of three elements, as depicted below.

ELEMENTS OF RURAL ACCESSIBILITY



These elements of rural transport involve the following:

- **Rural transport services and IMT: This includes any type of transport service rendered to communities; IMT includes bicycles and animal-drawn carts.**
- **Location and quality of facilities: Equally important is the location and quality of facilities, in particular the distance from households to facilities such as wells, forests, grinding mills, schools and health centers.**
- **Rural transport infrastructure (RTI) includes tracks, paths and footbridges, as explained in the box below.**

RURAL TRANSPORT INFRASTRUCTURE (RTI) DEFINED
(LEBO AND SCHELLING, P. 8)

RTI is the rural road, track, and path network on which the rural population performs its transport activities, which includes walking, transport by non-motorized and motorized vehicles, and haulage and transport of people by animals. RTI includes the intra- and near-village transport network, as well as the infrastructure that provides access to higher levels of the road network.

The *RTI network* is defined as “the lowest level of the physical transport chain that connects the rural population, and therefore the majority of the poor, to their farms, local markets, and social services, such as schools and health centers, potentially increasing their real income and improving their quality of life” (Lebo and Schelling, p. 9). Key features of RTI are as follows:

- **Ownership: RTI is normally owned by local governments and communities.**
- **Managing and financing: Many different arrangements may exist for managing and financing RTI.**
- **Physical features: RTI connects villages to the higher classified road network. These links are normally relatively short (less than 20 kilometers) and sometimes at least partly engineered.**
- **Traffic characteristics: Transport activities generally are at a much lower level than on main road networks. They are a combination of pedestrians, intermediate means of transport (IMT) such as bicycles and animal-drawn carts, and motorized transport.**

Minimum criteria for basic access RTI are as follows:

- **Passability or reliability**
- **Adequate access to higher level networks**
- **Adequate access to local social and economic facilities**
- **Adequate access to domestic activities**
- **Trafficable by prevailing rural transport vehicle**

Basic access is defined as the minimum level of service of the RTI network that is required to ensure sustained socio-economic activity. Basic access is therefore one of the necessary building blocks of poverty reduction. In its turn, a *basic access intervention* is defined as “the least-cost (in terms of total lifecycle cost) intervention for ensuring reliable, all-season passability for the locally prevailing means of transport” (Lebo and Schelling, p. 1). Design features of RTI for basic access typically will include spot improvement and the adoption of labor-based methods. Given the decentralized framework for the provision of services at a local level, it is important that the planning process (including appraisal), should be participatory. The local government or community transport plan will constitute a key tool for this participatory process. Candidate projects will be selected and ranked, using a combination of screening and ranking procedures. Regarding the latter, a cost-effectiveness analysis (CEA) is advocated, where a priority index will be calculated as the ratio of total life-cycle cost divided by the population to be served by the improved facility.

The main features of this approach are summarized below.

MAIN FEATURES OF BAA
(LEBO AND SCHELLING, P. 3)

In order to complement poverty reduction strategies, rural transport interventions must be an integral part of rural development interventions and focus on the mobility and access needs of rural communities. Substantial gains in accessibility – for more communities, in more regions of a country – are possible if rural transport infrastructure interventions are designed in a least-cost, network-based manner focusing on eliminating trouble spots. In view of budget constraints, selecting interventions requires a participatory physical planning process undertaken jointly with concerned local governments and communities, supported and coordinated by regional or central government agencies. Simple screening methods facilitate the selection process, reducing the number of alternatives to a manageable level. Ranking is then applied to the remaining options, and in most cases (below 50 VPD) the use of cost-effectiveness methods is recommended, supported by sample cost-benefit analysis on selected links, where appropriate.

4.3. EXPECTED RESULTS AND OUTCOME

BAA ensures that RTI (rural transport infrastructure) is provided in such a manner that the basic access needs of rural communities are met. By doing this, RTI can play its rightful role in complementing the higher order main road network. By addressing the shortcomings of traditional approaches to road management which focus on *main road networks*, to the detriment of *rural networks*, BAA enables agencies to adopt a holistic approach in managing the network, considering the whole spectrum of roads, from “social roads” to “economic roads”.

4.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

BAA can contribute to a number of management functions. It is particularly relevant to network needs assessment which, with the specific focus on the role of roads in poverty alleviation, involves the recognition of rural transport infrastructure as a critical element of poverty alleviation initiatives. This requires the right balance between investing in the main road network (ensuring national connectivity) and rural roads (ensuring basic access) in order to maximize the positive impact of poverty reduction initiatives. BAA addresses the shortcomings of traditional approaches to road management which focus on *main road networks*, to the detriment of *rural networks*.

4.5. FACTORS AFFECTING APPLICATION

Limitations regarding the application of BAA, especially in the case of spot improvements, are listed in the box below. Cost may also be a consideration. Cases have been noted where consultants’ services for participatory processes involving rural communities were as expensive as the works themselves.

LIMITATIONS REGARDING THE USE OF BAA
(LEBO AND SCHELLING, P. 14)

Political pressure:

Politicians who are responsible for marshalling funds (including donor financing) for sector investments must answer to their constituencies, and therefore are under pressure to demonstrate effective and visible outcomes. This often leads to a decision to rehabilitate roads to fully engineered standards, rather than to undertake less visible spot improvements.

Road agency resistance:

Road engineers and managers want to remove particularly troublesome roads from their work programs. They may also view it as inappropriate to use "borrowed" donor money to produce what could be considered an inferior product. Many engineers are not well-informed about the merits of the spot improvement approach.

Private sector incentives:

Contractors and consultants prefer continuous upgrading to spot improvements. Upgrading (which entails higher quantities of earth movements and materials) is often the basis for mark-ups and therefore directly affects profits. Smaller, decentralized, and less visible spot improvements are viewed as unprofitable and are also difficult to define and supervise. Small-scale local contractors, however, may find this type of work very suitable.

Donor preferences:

Donor agencies often prefer a fully rehabilitated road to the process of identifying and financing investments in a series of dispersed trouble spots. Individual project financing may favor a quickly executed fully engineered approach because of the short time frame and the requirement to fully disburse funds. However, a long-term program approach is more appropriate for the gradual spot-improvement of a rural access network.

For further information, consult the World Bank Technical Paper No 496 "Design and Appraisal of Rural Transport Infrastructure" available on the SSATP website:

www.worldbank.org/afr/ssatp

BSC Balanced Scorecard

TO ENSURE THE OPTIMAL OUTCOME OF “road infrastructure management” (namely an effective and efficient road network), road authorities must be functioning optimally from an organization perspective. This will also ensure that available tools, such as those described in this document, are used optimally. The BSC approach is a generic tool for improving the overall performance of organizations. It is a management system that helps align key performance measures with vision and strategy and translate them into action. BSC also provides feedback on internal business processes and external outcomes. It facilitates communication and the understanding of business goals and strategies at all levels in the organization and thus improves feedback and learning.

5. BSC: Balanced Scorecard

5.1. BACKGROUND

To ensure the optimal outcome of "road infrastructure management", namely an effective and efficient road network, road authorities themselves must be functioning optimally from an organization perspective. When this happens, it will also ensure that available tools, such as those described in this document, are used optimally. It is however often found that traditional methods for assessing organizational performance are inadequate. Given the weaknesses and vagueness of these approaches, it is clear that there is a need for a new approach to inform management of organizational performance, using real and more appropriate performance measures. A particular challenge to be addressed by this "new approach" is the existence of barriers to optimal strategy execution, as detailed in the figure below.

BARRIERS TO IMPLEMENTING STRATEGY

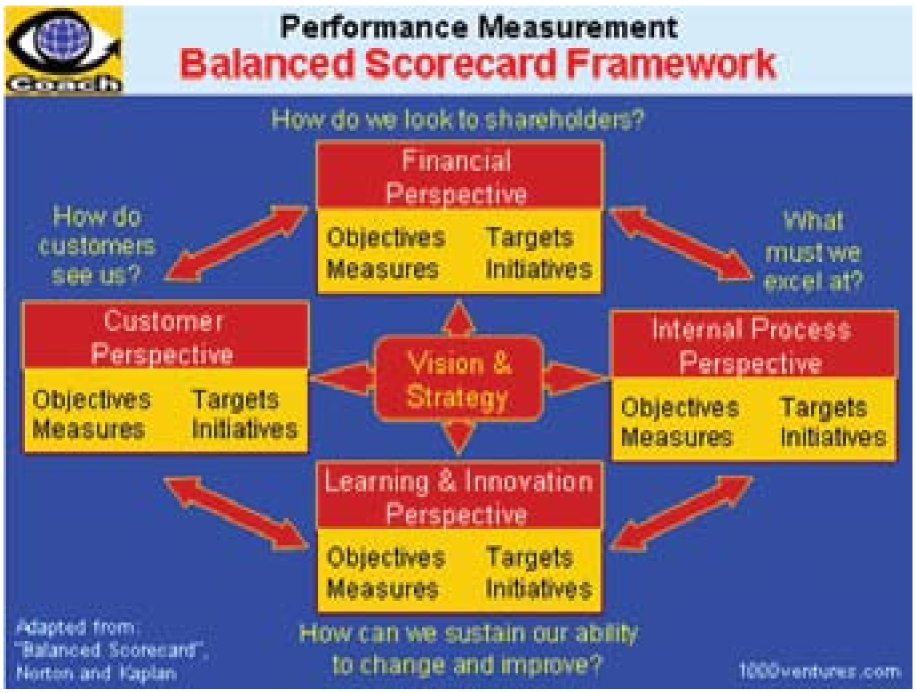
5.2. DESCRIPTION

The Balanced Scorecard (BSC) approach was developed in the early 1990s by Drs. Robert Kaplan (Harvard Business School) and David Norton, in response to the weakness of traditional performance measures for organizations in the private sector. It is described as "*a management system*" (not only a measurement system) that enables organizations to clarify their vision and strategy and translate them into action. It provides feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results. When fully deployed, the balanced scorecard transforms strategic planning from an academic exercise into the nerve center of an enterprise (Balanced Scorecard Institute website).

The link between BSC and traditional financial performance measure is described as follows: “The balanced scorecard retains traditional financial measures. But financial measures tell the story of past events, an adequate story for industrial age companies for which investments in long-term capabilities and customer relationships were not critical for success. These financial measures are inadequate, however, for guiding and evaluating the journey that information age companies must make to create future value through investment in customers, suppliers, employees, processes, technology, and innovation” (Kaplan and Norton, on “Balanced Scorecard Institute” website).

The process of developing a BSC begins with the vision and strategies of the organization. It then proceeds toward the formulation of critical success factors and, finally, an agreement on performance measures for each of the four organizational perspectives. The relationship between these four perspectives, and “vision and strategy”, is indicated in the figure below.

VISION, STRATEGY, AND ORGANIZATIONAL PERSPECTIVES



BSC involves a number of specific steps outlined below.

STEPS INVOLVED IN THE SCORECARD BUILDING PROCESS

- Step One: (a) Assessment of the organization's mission and vision, challenges, enablers and values; (b) preparation of change management plan; and (c) conducting a communications workshop to identify key messages, media outlets, timing and messengers.
- Step Two: Development of elements of organization's strategy, including strategic results, themes and perspectives, in order to focus attention on customer needs and organization's value proposition.
- Step Three: Decomposition of strategic elements (developed in the first two steps) into strategic objectives – they are the basic building blocks of strategy and define the strategic content of the organization.
- Step Four: Formalization (in an organization wide strategy map) of the cause and effect linkages between organization-wide strategic objectives.
- Step Five: Development of performance measures for each of the organization-wide strategic objectives.
- Step Six: Development of strategic initiatives that support the strategic objectives, assigning ownership of performance measures and strategic initiatives to appropriate staff in order to build accountability throughout the organization.
- Step Seven: Implementation of the process by applying performance measurement software.
- Step Eight: Cascading down of the organization-level scorecard into the scorecards of business and support units. This translates high-level strategy into lower-level objectives, measures, and operational details.
- Step Nine: Evaluation of the completed scorecard, and corrective action where necessary.

5.3 EXPECTED RESULTS AND OUTCOME

The results and outcome of the BSC approach follow from the logic of the process, as depicted in the figure below.

LOGIC OF BSC PLANNING

The application of this logic translates into a number of specific benefits with reference to organizational performance, as summarized in the box below.

BENEFITS FROM USING BSC

- Balanced Scorecard helps align key performance measures with strategy at all levels of an organization
- Balanced Scorecard provides management with a comprehensive picture of business operations
- The methodology facilitates communication and understanding of business goals and strategies at all levels of an organization
- The balanced scorecard concept provides strategic feedback and learning

5.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Monitoring road authority performance is aimed at ensuring that the authority responsible for managing the road network is functioning optimally (i.e. both effectively and efficiently). By providing feedback needed for the ongoing improvement of the strategic performance and results of an organization, the BSC facilitates the optimal functioning of the road authority.

5.5. FACTORS AFFECTING APPLICATION

It is not known if this approach has been utilized in any road authority in the region. This very fact may limit the use of the BSC technique in the region as road authorities may be unwilling to apply this approach and/or implement its findings.

www.balancedscorecard.org → BSC Resources

DEFINITE DEcision on a FINITE set of Alternatives

ROAD AUTHORITIES MUST ENSURE THAT the communities they serve get value for their money and that optimal investment portfolios are chosen. In addition to including all criteria in the decision-making process, this requires project feasibility to be expressed as a single, numerical figure. In a multi-criteria decision-making environment, this often is difficult for a number of reasons: criteria may be conflicting, they may not be expressed in the same units, or they may be difficult to quantify. Incorporating current thinking and state-of-the-art technology, the DEFINITE software package provides a single measure of project feasibility in a multi-criteria decision-making environment. The process involves identifying and dimensioning decision criteria, and "scoring" investment options in a manner that is scientifically defendable and transparent. DEFINITE enables road authorities to rank investment proposals in terms of their overall feasibility and to select investment portfolios that maximize "value for money".

6. DEFINITE: DEcisions on a FINITE Set of Alternatives

6.1. INTRODUCTION

There are a number of tools available for decision-making in a multi-criteria decision-making context, and which express overall project feasibility as a single numerical measure for use in project prioritization. The software package DEFINITE has been selected as the preferred tool, given criteria relevant to the selection of appropriate electronic management tools such as simplicity, cost, hardware requirements, access and maintenance, transparency and scientific rigor.

6.2. BACKGROUND

In order to make a final decision regarding a proposed investment to improve or expand the road network, it is important that all likely impacts resulting from this intervention are identified and quantified, and included in the decision-making process. This means that the "worth" (feasibility) of each investment proposal has to be determined. In fact, the accurate assessment of "project worth" constitutes a prerequisite for informed decision-making.

For the purpose of this chapter, "project worth" is defined as the degree of alignment of project impacts with decision criteria (the latter being derived from policy goals and objectives at national, regional and local level). In the case of road infrastructure projects, impacts are typically *diverse* in nature and as well as *permanent* (the latter because of the long economic life of the road asset).

In measuring impacts, a number of problems may be encountered. For example, impacts may be *contradictory* or *overlapping*, expressed in *different units* or *not quantifiable* at all. These problems (described below) contribute to the fact that expressing "project worth" as a single number or score in most cases is difficult, if not impossible:

- **Economic efficiency and equity are examples of conflicting impacts (criteria): efficiency considerations would normally direct investment to densely populated, affluent urban areas where, in the case of road infrastructure projects, high traffic volumes and high values of travel time will ensure that the project is economically justified. On the other hand, "equity" considerations would direct investment to lesser-developed (rural) areas, benefiting lower income groups.**
- **Job creation and income levels are examples of overlapping impacts (criteria), as an improvement in the one normally is associated with a corresponding improvement in the other. With overlapping impacts, double counting can easily occur.**
- **Different impacts may be expressed in different units. For example, the impact "economic efficiency" may be expressed in different ways, e.g. as a ratio (benefit-cost ratio) or as a percentage (rate of return). "Job creation", as an example of another type of impact, is likely to be expressed as "number of jobs additional to the base case".**
- **Some impacts can only be expressed in qualitative terms.**

These “problems” in measuring impacts (given the need to include *all* impacts in decision-making) imply project evaluation and decision-making in a multi-criteria context. They also call for an understanding of the underlying theory of multi-criteria decision-making and available tools for facilitating project evaluation and selection in a multi-criteria decision-making environment. It thus follows that there is a need for a tool that can consolidate the results (outputs) of the other tools described in this document in a single decision-making tool.

6.3. DESCRIPTION

DEFINITE, developed by the Vrije Universiteit of Amsterdam in the Netherlands, is aimed at facilitating decision-making in a multi-criteria decision-making context which is typically characterized by the fact that decision criteria (impacts) are:

- **Conflicting**
- **Overlapping**
- **Expressed in different units**
- **Cannot be quantified**

In the supporting documentation, DEFINITE is described as follows: “DEFINITE (DEcisions on a FINITE set of alternatives) is a decision support software package that has been developed to improve the quality of decision-making. It is, in fact, a whole toolkit of methods that can be used on a wide variety of problems. If you have a problem to solve, and you can identify alternative solutions, then DEFINITE can weigh up the alternatives for you and select the best alternative. The program contains a number of methods for supporting problem definition as well as graphical methods to support representation. To be able to deal with all types of information, DEFINITE includes multi-criteria methods, cost-benefit analysis and graphical evaluation methods. Related procedures, such as weight assessment, standardization, discounting and a large variety of methods for sensitivity analysis are also available. A unique feature of DEFINITE is a procedure that systematically leads an expert through a number of rounds of an integrative assessment session and uses an optimization approach to integrate all information provided by the expert to a full set of value functions. DEFINITE supports the whole decision-making process, from problem definition to report generation. The structured approach ensures that the decision arrived at is systematic and consistent. DEFINITE can be used by the busy professional with no prior experience of such software, as well as the sophisticated user” (Vrije Universiteit van Amsterdam, 1994).

DEFINITE has a wide variety of users. Within the Dutch government, users include almost all ministries, provinces, public bodies and a number of larger cities. Outside government, the main users are consultancy and engineering firms.

6.4. EXPECTED RESULTS AND OUTCOME

The quality of the outputs of DEFINITE is inextricably linked to its features. Important features regarding *input* format and calculation are listed below.

DEFINITE FEATURES REGARDING INPUT FORMAT AND CALCULATION	
7 measurement scales: • Ratio scale • Interval scale • Monetary scale • Ordinal scale • ---/+++ scale • Nominal scale • Binary scale	**7 standardization methods:** • Maximum standardization • Interval standardization • Goal standardization • Convex standardization • Concave standardization • S-shape standardization • Free form standardization
5 methods for determining criteria weights: • Direct assessment • Pairwise comparison • Expected value method • Random weights • Extreme weights	**4 methods for multi-criteria analysis:** • Weighted summation • Electre 2 method • Regime method • Evamix method

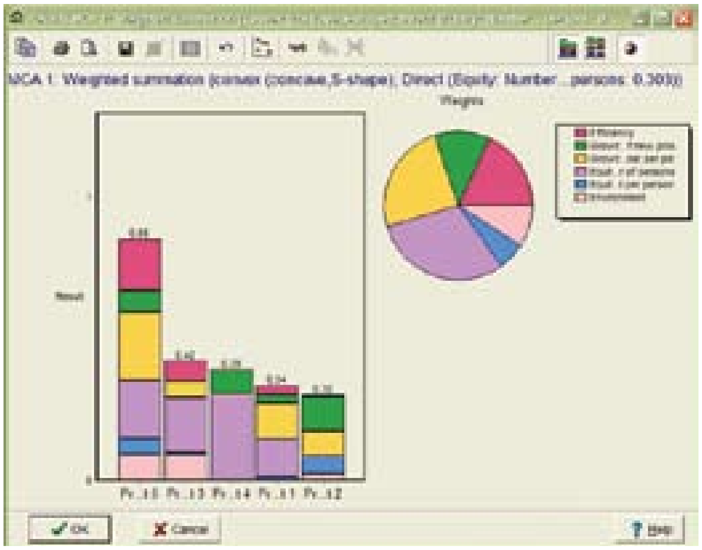
Important features regarding *output* from DEFINITE can be classified under the following headings:

- **Graphical output: Various options are available for presenting output in graphical format (in addition to tabular format).**
- **Results can be analyzed in terms of both:**
  - **Uncertainty**
  - **Sensitivity (test for robustness of ranking)**

The figures below show two options for the graphical presentation of DEFINITE outputs in the case of five (hypothetical) projects analyzed in terms of four groups of decision criteria:

- **Efficiency**
- **Macro-economic (economic growth)**
- **Socio-economic (equity)**
- **Environment**

GRAPHICAL PRESENTATION OF DEFINITE OUTPUTS (OPTION 1)



Source: Vrije Universiteit van Amsterdam, 1994

GRAPHICAL PRESENTATION OF DEFINITE OUTPUTS (OPTION 2)

Source: Vrije Universiteit van Amsterdam, 1994

As shown above, DEFINITE quantifies "project worth", which is a single measure of the overall feasibility of an investment option in a multi-criteria decision-making environment. By doing this, DEFINITE enables the road agency to make investment decisions that are optimally aligned with the whole spectrum of criteria which often are conflicting and/or difficult to quantify (if at all).

6.5. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Network needs assessment and the appraisal or ranking of investment options require that all impacts of proposed projects are considered in project appraisal and prioritization. To facilitate the process, it also implies that "project worth" (feasibility) preferably must be expressed as a single numeric figure reflecting the overall feasibility of an investment option in a multi-criteria decision-making environment. DEFINITE provides a scientific method for quantifying "project worth", enabling road authorities to make decisions that are optimally aligned with relevant criteria and to select investment portfolios that maximize "value for money" to taxpayers.

6.6. FACTORS AFFECTING APPLICATION

6.6.1 Previous applications

DEFINITE has not yet been widely applied to transport infrastructure projects. A current initiative in South Africa is in fact aimed at investigating the potential of DEFINITE for improving decision-making in the transport sector and ensuring better governance outcomes and addressing challenges in this regard. The focus with this initiative is *"routine"* (smaller) projects of a *repetitive* nature (e.g. projects to be evaluated, ranked and selected on an annual basis (annual budget cycle), rather than "one-off", big and unique projects.

6.6.2. Limitations

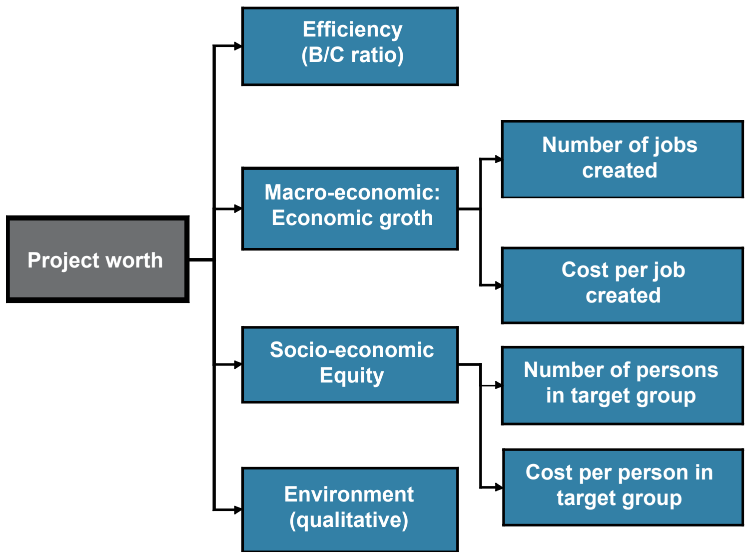
Limitations (or challenges) in respect of the use of DEFINITE are the following:

- **Getting agreement (consensus) on goals and objectives.**
- **Quantification of certain impacts.**
- **Lack of expertise and experience at both technical and political level.**
- **Data availability.**
- **"Need" for political "freedom" (autonomy): The decision makers may wish to approve a project "for political reasons"; DEFINITE may not allow them that "freedom" as the decision criteria included are supposed to be comprehensive (all inclusive).**

6.6.3 Data requirements

Data requirements may be extensive, as is evident from the figure below showing the "value tree" (or "hierarchy of criteria") typically applicable to transport infrastructure projects, and the table based on this value tree, showing "scores" for a hypothetical set of projects.

EXAMPLE OF A VALUE TREE



PROJECT SCORING

Criteria	Measurement unit	Actual performance						
		Proj	Proj2	Proj3	Proj4	Proj5	Proj6	Proj7
Economic efficiency	B/C ratio	1.40	1.10	1.70	1.05	2.10	1.05	1.10
Macro-economic impacts								
Employment	Number of new jobs	200	500	150	350	300	400	300
Cost of employment	Cost per job (R million)	0.32	0.39	0.50	0.73	0.15	0.12	0.29
Socio-economic impacts								
Extent	Number of per-sons to benefit	150	100	750	1,600	800	350	250
Associated cost	Cost per per-son (R million)	0.44	0.05	0.63	0.60	0.32	1.44	0.55
Environment	Qualitative	- - -	- -	0	- - - -	-	- -	0

6.6.4 Customizing to local needs

Customizing DEFINITE to local needs would involve both the development and maintenance of an appropriate database, and the provision of training.

6.6.5 Cost involved

Cost implications are discussed under three headings:

- **Cost of acquiring and maintaining software: Small compared to other costs.**
- **Cost of training: Training should take place at both a technical and decision-making (political) level in order to ensure the successful use of this tool. This cost may be high.**
- **Cost of data collection, verification and maintenance: This will also be considerable.**

For further information on DEFINITE, visit the IVM/Institute for Environmental Studies website:

www.ivm.falw.vu.nl/home → Research Projects → Alphabetical List of Projects

HDM Highway Development and Management Model

IN ORDER TO ENSURE THE OPTIMAL ALLOCATION of scarce resources, interventions in road infrastructure at all levels – strategy, program and project level – must be economically analyzed. Analysis at the strategy level involves, *firstly*, forecasting (a) of long-term funding requirements for target road maintenance standards and (b) of long-term road network performance under varying funding levels, *secondly*, optimal fund allocation (a) to defined budget heads and (b) to sub-networks, and *thirdly*, policy studies, e.g. impacts of changes to the axle load limit, pavement maintenance standards, energy balance analysis, provision of NMT facilities, sustainable road network size, and analysis of pavement design standards. HDM-4 (at the strategy level) assists the road authority in doing all this. The results obtained enable the road authority to make the optimal use of available resources; alternatively, to motivate for additional funds by pointing out the consequences of insufficient funding.

Interventions in road infrastructure at all levels must be economically justified to ensure the optimal allocation of scarce resources. At the program level, road authorities are required to prepare one-year and/ or multi-year work programs under conditions of budget constraints. HDM-4 (program level) assists road authorities in doing this by identifying optimal combinations of maintenance and improvement options, i.e. sections or options that, collectively, maximize return on investment. In this way, HDM-4 ensures that maintenance and improvement programs are optimal and that the best use is made of taxpayer's money.

To ensure the responsible allocation of scarce resources, interventions in road infrastructure at all levels – strategy, program and project level – must be economically analyzed. HDM-4 (project level) is a tool for accomplishing this at the project level. Projects could include the maintenance and rehabilitation of existing roads, the widening or geometric improvement of existing roads, pavement upgrading as well as new construction. Analysis at the project level involves determining if discounted benefits of the project over the analysis period at least are equal to its discounted costs. In doing this, HDM-4 assists agencies in making investment decisions at the project level that best contribute to the overall objective of reducing transport cost.

7. HDM: Highway Development and Management Model

7.1. BACKGROUND

In managing the road network under the jurisdiction of a given authority, it is important that actions taken at different management levels are justified from all relevant perspectives to ensure that a sustainable road network will result which minimizes long-term transport cost (given budget constraints) and which creates an environment conducive to economic growth and development. This has implications for analyses at the strategy level, the program level and the project level, as explained in the boxes below.

STRATEGY ANALYSIS
(KERALI, PP. 13-14)

Typical examples of strategy analysis by road agencies would include the following:

- Medium to long term forecasts of funding requirements for specified target road maintenance standards.
- Forecasts of long term road network performance under varying levels of funding.
- Optimal allocation of funds according to defined budget heads; for example routine maintenance, periodic maintenance and development (capital) budgets.
- Optimal allocations of funds to sub-networks; for example by functional road class (main, feeder and urban roads, etc.) or by administrative region.
- Policy studies such as impact of changes to the axle load limit, pavement maintenance standards, energy balance analysis, provision of NMT facilities, sustainable road network size, evaluation of pavement design standards, etc.

PROGRAM ANALYSIS
(KERALI, P. 17)

Program analysis "… deals primarily with the prioritization of a defined long list of candidate road projects into a one-year or multi-year work program under defined budget constraints".

PROJECT ANALYSIS
(KERALI, P. 19)

Project analysis deals with the "…evaluation of one or more road projects or investment options. The application analyses a road link or section with user-selected treatments, with associated costs and benefits, projected annually over the analysis period. Economic indicators are determined for the different investment options". Projects may typically include "… the maintenance and rehabilitation of existing roads, widening or geometric improvement schemes, pavement upgrading and new construction".

7.2. DESCRIPTION

7.2.1 Purpose

The Highway Development and Management (HDM-4) model is aimed at facilitating the analysis of alternatives in respect of road maintenance and investment. It focuses on the technical and economic appraisal of *road projects*, the preparation of road investment *programs* as well as the analysis of road network *strategies*. The essence and "mechanics" for accomplishing this are explained in the boxes below.

HDM-4 DESCRIPTION IN WORLD BANK REPORT ON SUCCESS FACTORS FOR ROAD MANAGEMENT SYSTEMS

(MCPHERSON AND BENNETT, P. 39)

HDM-4 is a tool for economic optimization of maintenance of road networks and has been adopted or applied in many different countries for economic analysis and prioritization. HDM-4 can operate with Strategy, Program and Project analysis. It utilizes road network inventory and condition, traffic and economic data to feed a series of road deterioration models and cost models, and to formulate candidate work programs for road networks.

HDM-4: THE ESSENCE

(KERALI, P. 20)

The model simulates, for each road section, year-by-year, the road condition and resources used for maintenance under each strategy, as well as the vehicle speeds and physical resources consumed by vehicle operation. After physical quantities involved in construction, road works and vehicle operation are estimated, user-specified prices and unit costs are applied to determine financial and economic costs. Relative benefits are then calculated for different alternatives, followed by present value and rate of return computations.

7.2.2 Historical perspective

Since HDM-4 (including its predecessors and other related products) constitutes pioneering work in the domain of road management and "paved the way" for other tools to follow, it is necessary to consider its historical context.

The first step to produce a "road project appraisal model" was taken by the World Bank in 1968. It involved a "highway design study", the Terms of Reference of which was produced by the World Bank, the Transport and Road Research Laboratory (TRRL) and the *Laboratoire Central des Ponts et Chaussées* (LCPC).

A second study was commissioned by the World Bank, involving the Massachusetts Institute of Technology (MIT), with the objective of carrying out a literature survey and constructing a model based on available information. This resulted in the Highway Cost Model (HCM).

Subsequent to this, the TRRL, in collaboration with the World Bank, did a major field study in Kenya to investigate the deterioration of paved and unpaved roads, including factors affecting vehicle operating cost (VOC) in a developing country. This led to the development of the first prototype version of RTIM (Road Transport Investment Model) by TRRL. In the meantime (1976), the World Bank funded further developments of HCM at MIT which led to the first version of the HDM (Highway Design and Maintenance Standards) model.

A number of further studies followed:

- **The Caribbean study was undertaken by TRRL (1982), focusing on the effects of road geometry on vehicle operating costs.**
- **The India study was carried out by the Central Road Research Institute (CRRI), addressing operational problems of Indian roads in terms of narrow pavements and the large proportions of non-motorized transport.**
- **The Brazil study, funded by UNDP, focused on extending the validity of all of the model relationships.**

The results of TRRL studies were incorporated in the RTIM2 model, whereas the World Bank consolidated research findings into the HDM-III model. Both these models, originally developed for mainframe computers, were subsequently converted to micro-computer models. RTIM2 was updated to RTIM3 in 1993, providing a user-friendly version of running on a spreadsheet. Regarding HDM-III, two further versions were produced in 1994, namely HDM-Q (incorporating the effects of traffic congestion) and HDM Manager (providing a menu-driven front end to HDM-III).

HDM-4, which is the current version of the HDM model, was developed in response to a number of needs:

- **The need for “a fundamental redevelopment of the various models to incorporate a wider range of pavement and conditions of use, and to reflect modern computing practice and expectations" (Kerali, p. 4).**
- **The need to update the technical relationships (regarding vehicle operating costs) to reflect the state-of-the-art.**
- **The need to apply the model in industrialized countries, which requires additional capabilities such as:**
  - **Traffic congestion effects**
  - **Cold climate effects**
  - **A wider range of pavement types and structures**
  - **Road safety**
  - **Environmental effects, e.g. energy consumption, traffic noise and vehicle emissions**

7.2.3 Scope

Based on the concept of "road life cycle", HDM-4 has four sets of models to predict various aspects of roads over their technical life:

- ***Road deterioration model*, which predicts pavement deterioration for bituminous, concrete and unsealed roads. This is done by considering the consequence of impacts such as traffic loading, environmental weathering and inadequate drainage systems.**
- ***Road works effects model*, which simulates the impact of road works on pavement condition and determines the corresponding costs.**
- ***Road user effects model*, which calculates the cost of vehicle operation, road accidents and travel time cost.**
- ***Socio-economic and environmental effects model*, which determines the effects of vehicle emissions and energy consumption.**

7.2.4 Data managers

HDM-4 operates on data defined in one of four data managers as shown in the box below.

DATA MANAGERS IN HDM-4

(KERALI, P. 20)

- Road Network: Defines the physical characteristics of road sections in a network or sub-network to be analyzed.
- Vehicle Fleet: Defines the characteristics of the vehicle fleet that operate on the road network to be analyzed.
- Road Works: Defines maintenance and improvement standards, together with their unit costs, which will be applied to the different road sections to be analyzed.
- HDM Configuration: Defines the default data to be used in the applications. A set of default data is provided when HDM-4 is first installed, but users should modify these to reflect local environments and circumstances.

7.2.5 Improvements in the latest version of HDM-4

Major improvements included in HDM-4 Version 2.0 (relative to Version 1.3) are listed below under appropriate headings. More details will appear shortly on the HDM Global website.

New analysis models/tools

- **Sensitivity Analysis to allow a user to investigate the impact of variations in key parameters on the analysis results.**
- **Budget Scenario Analysis to allow a user to compare the effects of different funding levels on the network being analyzed.**
- **Multi-Criteria Analysis (MCA) provides a means of comparing projects using criteria that cannot easily be assigned an economic cost.**
- **Asset Valuation to provide a means to estimate the financial and economic value of road assets as a function of the level of investment.**

Improved connectivity with external systems

- **Data exchanged in a more common format (Microsoft Access).**
- **Road Network and Vehicle Fleet data validated when imported.**

Improved data handling and organization

- **Redesign of New Section facilities for greater reuse.**
- **Traffic redesign to better reflect the way data is used**.

Improved technical models

- **Bituminous Road Deterioration and Work Effects updated for better calibration and improved modeling.**
- **Unsealed Road Deterioration and Work Effects updated for better calibration. Road User Effects updated for improved results.**
- **Emissions updated with new relationships for improved results**.

Improved usability and configuration

- **Advanced Intervention Editor and work item triggering logic.**
- **Improved Alternatives User-Interface to provide greater feedback to the user without the need to continually open and close dialogs.**
- **Post-Improvement Maintenance Standards can be defined for responsive improvements.**

- **Calibration Sets introduced to aid the definition of a section by reusing common calibration characteristics of sections.**
- **Accident Classes introduced to improve accident rate analysis.**

7.3. EXPECTED RESULTS AND OUTCOME

HDM-4 produces information that facilitates road management decisions at three levels: strategy, program and project levels. Results are described in the boxes below with reference to the objective for each case.

STRATEGY LEVEL

Results at this level can be classified under three headings:

- Forecasting: This includes forecasts of funding requirements for specified target road maintenance standards, and forecasts of long-term network performance under varying funding levels.
- Optimal allocation of funds: This includes the optimal allocation of funds to defined budget heads (e.g. routine maintenance, periodic maintenance, new projects), and the optimal allocation of funds to sub-networks (e.g. functional road class or administrative region).
- Policy studies: This could involve aspects such as changes in axle load limit, pavement maintenance standards, energy balance, the provision of non-motorized transport, sustainable road network size, and pavement design standards.

PROGRAM LEVEL

One-year or multi-year work programs under defined budget constraints, which in essence constitutes the ranking of a defined long list of candidate projects.

PROJECT LEVEL

Results at the project level involve an indication of the best engineering and economic alternative in the case of one or more road projects or investment options.

7.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

As is evident from the paragraphs below, HDM-4 can contribute to a number of management functions, e.g. road sector policies formulation, network needs assessment, programming road expenditures and the preparation of road projects.

Setting appropriate standards

HDM-4 (at the strategy level) can help setting appropriate performance standards for the road network by determining the funding requirements for a defined network standard and, conversely, by indicating the resulting network standard for a given funding level. The results obtained enable the agency to plan for sufficient funding, alternatively, to indicate the consequences of insufficient funding.

Asset preservation

HDM-4 (at all levels but in particular at the program level) can assist in preserving the current road network by identifying appropriate actions to maintain and preserve the network, e.g. by identifying optimal combinations of road sections to be earmarked for maintenance and improvement, involving one-year or multi-year work programs under conditions of budget constraints.

Appraisal and ranking of investment options

HDM-4 (at the project level) is a tool for ensuring that an investment in the road network is economically justified. By ensuring that discounted benefits exceed (or at least are equal to) discounted costs over the economic life of the project, HM-4 enables agencies to make optimal investment decisions that minimize total transport cost.

7.5. FACTORS AFFECTING APPLICATION

7.5.1 Previous applications

HDM-4 (in all its versions) has been used in over 100 countries. These were mostly developing countries. As many developed countries have also started using HDM-4 in recent times, there was a need to address typical "developed country" impacts and contexts (also discussed in Chapter 5.2.2), namely:

- **Traffic congestion effects**
- **Cold climate effects**
- **A wider range of pavement types and structures**
- **Road safety**
- **Environmental effects (energy consumption, traffic noise and vehicle emissions)**

7.5.2 Limitations

HDM-4 uses a wide spectrum of input data at a detailed/sophisticated level. Local data have to be adapted to the HDM-4 model, e.g. road user data, road and pavement data, traffic data, unit cost data and economic data. In order to provide meaningful results for a given country, HDM-4 also has to be calibrated for that country, in particular the Road User Effects model and the Road Deterioration and Maintenance Effects models. Data collection and model calibration may be time consuming and costly, constituting limiting factors in the application of HDM-4.

7.5.3 Data requirements and customizing to local needs

HDM-4 works with a wide range of data type and quality. Input data can be classified under the headings *road networks*, *vehicle fleets* and *road works*. As explained above, the customization (calibration) HDM-4 may pose a problem that limits its use in a given country or by a given road agency.

7.5.4 Cost

Indicative figures for the cost of various options for acquiring HDM-4 are given in the table below. However, in addition to the initial cost of acquiring the software, the cost of gathering, calibrating and updating data required by the software should be considered, and this may be substantial.

TYPE OF LICENSE	PRICE (US$)
Full license	3,000
Upgrade V1.x license (only during the first year after the license is obtained)	1,800
Countries with low income and low intermediate income (SCC) Full license	2,000
Countries with low income and low intermediate income (SCC) Upgrade V1.x license (only during the first year after the license is obtained)	1,200
Pack 4 licenses, per license	2,550
Pack of more than 4 licenses, per license	2,400

Further information is provided on the Global HDM website:

www.hdmglobal.com/

IRAP Integrated Rural Accessibility Planning

SPECIFIC ATTENTION MUST BE PAID to the accessibility needs of rural households in terms of basic social and economic services, given the notion “roads are not enough”. IRAP addresses the accessibility needs of rural households for subsistence, social and economic purposes, to counteract the traditional focus on “higher level” (national) road infrastructure. Key features of IRAP are the integration of elements such as physical infrastructure, means of transport, location planning and quality improvement of services, given the fact that roads alone are no guarantee for socio-economic development, and community involvement. IRAP, which involves a ten-step process, enables road authorities to accommodate the accessibility needs of rural communities in road infrastructure management.

8. IRAP: Integrated Rural Accessibility Planning

8.1. BACKGROUND

In order to develop a set of well-defined interventions that address the accessibility needs of a rural community, ranked in terms of acceptable criteria, it is necessary to determine the access needs of rural households as they pertain to basic social and economic services. Appropriate access interventions must then be identified, following the gathering of comprehensive information on aspects such as the location, condition and use or rural infrastructure and services, priorities and investment. In implementing and maintaining locally initiated projects, it is further necessary to build local capacity, to ensure that use is made of local resources (both human and material resources), and to promote the adoption of appropriate technologies and the use of labor-intensive methodologies. The growing realization that “roads are not enough” but that more emphasis is needed on basic access in an integrated and participative manner, has led to the need for a formal evaluation tool to provide in the need for a coherent basis for investing in improved accessibility, allowing different options for investing in infrastructure, means of transport, and coverage of services to be compared.

8.2. DESCRIPTION

Integrated Rural Accessibility Planning (IRAP) is described as “a multi-sectoral, integrated planning tool that addresses the major aspects of access needs of rural households for subsistence, social and economic purposes. The tool integrates the access and mobility needs of the rural population, the locations of basic social-economic services and the transport infrastructure in all sectors. IRAP is participatory and pro-active: it involves communities in all stages of the planning and creates a platform for local level planners and beneficiaries to pro-actively plan for development” (Dingen, p. xiii). It involves not only the improvement of the physical infrastructure (by constructing and improving roads, footpaths and bridges), but also concepts such as “means of transport”, “location planning” and “quality improvement of services”. From this it is clear that the focus is on improving access to socio-economic services in an attempt to reduce poverty and contribute to the social and economic well-being of the community and ultimately, the country. Important features of IRAP are as follows (Dingen, p. 8):

- **IRAP is integrated and multi-sectoral; it looks at all sectors, as well as the people and the system in which transport and travel exist.**
- **IRAP is a tool that provides practical assistance in planning.**
- **IRAP can be applied at village, area and district level.**
- **IRAP is based on primary data collection and participatory consensus building.**

Development of IRAP by the ILO started in the late 1980s as a response to the growing realization that a continued focus on “higher level” road infrastructure was not sufficient to address the issue of poverty alleviation. Research stimulated by initial findings continued during the 1990s. Important concepts in the IRAP context are defined in the box below:

IMPORTANT CONCEPTS IN THE IRAP CONTEXT
(DINGEN, P. 2)

Mobility (being mobile) is defined as the ease or the difficulty with which people and goods move from one point to another (the origin and destination). Mobility is associated with the transport infrastructures as well as the means of travel and transport.

Accessibility is defined as the ease or difficulty of reaching or using a facility or service. It relates to the availability of a service or its location as well as the mobility aspects.

Rural Transport and Accessibility examines the transport needs, the way people travel and what goods are transported, who carries the burden of transport, where it is carried to and what can be done to improve access for the rural population.

IRAP consists of ten steps, as described below.

TEN STEPS OF IRAP
(DINGEN, P. iii)

Data collection (step 1) is the first exercise. Enumerators hold interviews with key-informants of target villages in the district, using a questionnaire that contains questions on accessibility in all sectors, like drinking water, agricultural marketing, health, education, etc. It collects data on the existing transport, travel and access problems and prioritizes possible interventions for improvement.

Data Processing (step 2) involves data encoding and processing into a computerized database.

Data Analysis (step 3) of the encoded data will lead to specific information on access in all sectors. The information can be grouped for different administrative levels. Tables and graphs help the users to interpret the results.

Mapping (step 4) assists visualization of the accessibility situation. Combining maps and overlays of different sectors will help to identify the best possible solutions to achieve integrated and cost effective access interventions.

Validation workshops (step 5) are held to verify the data analysis output and to formulate and discuss the access problems and priorities and to identify interventions with the representatives of the Village Development Committees (VDCs).

Compilation of Access Profiles (step 6) is done following collection of the access information after verification in the workshops. The combinations of the output from the analysis and the maps form a profile of the accessibility of an area. An Area Accessibility Profile will include ranked villages and VDCs for each sector. The Profile furthermore provides descriptive information on facilities and services. The most urgent accessibility problems, as perceived by the people themselves, are listed. Preliminary solutions suggested by the villagers are also mentioned. The "objective" numerical (access) ranking is compared to the more subjective, perceived problems and proposed interventions.

Setting Accessibility Targets (step 7) is the next step in the process. Having identified accessibility problems in each sector and cross sectorally, realistic targets and objectives at local level are defined.

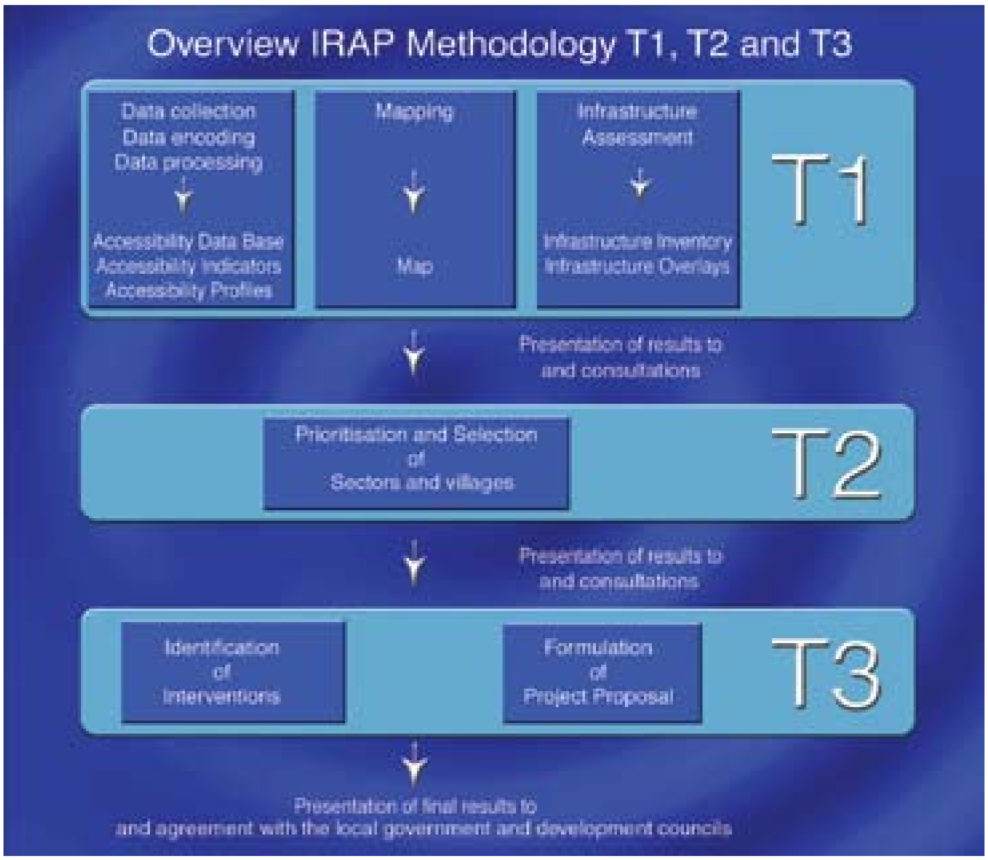
Prioritization and Formulation of Interventions (step 8) is the next logical step in addressing accessibility needs at both area and district level. The district authorities can pro-actively formulate proposals or alternatives to village proposals that go beyond the scope of individual villages or VDCs. It is now possible to relate this assessment to district and sector targets.

Implementation (step 9) is the stage in which the proposed interventions (projects), identified in the Prioritization Process, are included in the overall district development projects and ready for implementation. IRAP in Malawi is introduced as a tool that can enhance and complement the District Development Planning System. Integration of the IRAP contributes to having a participatory method to assess the needs of the rural population. Planning becomes more effective and efficient.

Monitoring and Evaluation (step 10) is the final step in the IRAP cycle. Feedback is required to improve the effectiveness of all steps and the results of interventions have to be assessed against the defined targets and objectives and the intended outcomes.

IRAP tools used to facilitate these steps are shown in the figure below.

OVERVIEW OF IRAP METHODOLOGY



Source: ILO, 2003

8.3. EXPECTED RESULTS AND OUTCOME

One of the outputs of the data analysis process is “Accessibility Indicators” (AI). This parameter is described in the box below.

FEATURES OF ACCESSIBILITY INDICATORS
(DINGEN, P. 30)

- Accessibility Indicators show relative degrees of difficulty in accessing facilities and services.
- These “AIs” are defined for all sectors in which “access to” is important. Calculation of AIs is mostly done on the basis of travel time. However in some sectors queuing time is another important factor to be considered: the queuing time indicates the “pressure” on the facility, e.g. at boreholes and grinding mills.
- The Indicator quantifies the size of the demand from households and the degree of the transport burden in a given area.
- AI TT = TT * HH

in which:

- HH = Number of Households permanently residing in a given village, ward or area under consideration.
- TT = Travel Time or Transport Time that an average household spends to reach a facility or service.
- AI = Access Indicator, i.e. the multiplication of (travel or queuing) time and the number of households. This quantifies the level of difficulty with which households access a given need, facility or service; in household minutes.

Benefits of going the IRAP route are listed below (Dingen, p. 61):

- **The information obtained through the IRAP approach, provides valuable and crucial insight in the pertaining issues in rural development. This relevance, therefore, justifies the inclusion of IRAP in the local level planning.**
- **Mapping out accessibility provides a visual aid and, more importantly, clarifies the access situation, which through other means alone might not become clear.**
- **The planner and the beneficiaries are better equipped to pro-actively assess proposals for interventions.**
- **Cross-sectoral network planning becomes possible for infrastructure and alternative interventions like literacy classes for women, bicycle credits, spatial planning can now all result from one system.**

A key feature of IRAP is the *integration* of elements such as physical infrastructure, means of transport, location planning and quality improvement of services, given the notion that "roads are not enough". Another feature of IRAP is *community involvement*. IRAP, which addresses the access needs of rural households for subsistence, social and economic purposes in response to the traditional focus on "higher level" road infrastructure (by following a 10-step process), therefore enables agencies to incorporate the access needs of rural communities in managing the road network.

8.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

IRAP can contribute to various road management functions. It is of particular value in the case of network needs assessment. When focusing on the role of road infrastructure in poverty alleviation, needs assessment involves the recognition of rural transport infrastructure (social roads) as a critical element of poverty alleviation initiatives. It requires that accessibility needs of rural households in terms of basic social and economic services are addressed, given the notion that roads alone are not enough to accomplish this. As IRAP addresses the access needs of rural households for subsistence, social and economic purposes, in response to the traditional focus on "higher level" road infrastructure, it enables agencies to incorporate the access needs of rural communities in managing the road network.

8.5. FACTORS AFFECTING APPLICATION

Within the Sub-Sahara Africa region, IRAP has been applied in Malawi. It has also been applied extensively in a number of countries in the Asia Pacific region. In India, for example, it has been applied at the Gram Panchayat (cluster of villages) level (Donnges et al). (The Panchayat Raj structure consists of four administrative/financial levels: district level, block level, cluster of villages level and village level.)

In applying IRAP, it should be noted that the extent to which the following conditions are accepted (or not) constitutes a limitation (Dingen, p. 62):

- **Accessibility is a determining factor in rural development and needs to be accepted as such.**
- **The pro-active approach in planning will need to be adopted; proposals will not only need to be assessed but district and area officials should be fully involved in the planning process, opening and moderating dialogues with the beneficiaries.**
- **Specific training needs in IRAP activities need to be planned and provided for within the planning framework.**

Data requirements do not impose a problem, as data are collected in the rural communities through interviews with villagers. No measurement tools are needed for this – the only requirement is to have a sample which is statistically representative. Data analysis is also simple and does not require sophisticated analytical tools, just a spreadsheet. IRAP is therefore fully customized to local needs as data collected are determined by the accessibility problems particular to the rural communities which are surveyed. IRAP may further be relatively inexpensive when done by local consultants or NGOs, but this may not be the case if expatriates are involved. Also, the process has to be repeated in all communities, which may require a substantial number of surveyors. The process also takes time. The costs involved therefore are a function of all these variables.

For further information on IRAP, consult the Rural Access Technical paper "Integrated Rural Accessibility Planning" available on the International Labour Organization website:

www.ilo.org → Department and Offices → Employment Intensive Investment Programme→ Publications

LFA Logical Framework Analysis

THE SUCCESSFUL PLANNING, DESIGN and implementation of interventions at different levels (project, program and strategy level) require sound processes to be in place. For example, the existing situation must be thoroughly analyzed, a logical hierarchy of the means for achieving objectives must be established, potential risks to achieving objectives and sustainable outcomes must be identified, the means for monitoring and evaluating outputs and outcomes must be established, a summary of the project must be presented to stakeholders in a standard format, and the project must be monitored and reviewed during implementation. LFA provides a generic set of tools for doing this whilst, at the same time, recognizing the importance of stakeholder participation and effective communication. LFA enables agencies to plan, design, implement and evaluate projects in a manner that is internationally accepted and utilized.

9. LFA: Logical Framework Analysis

9.1. BACKGROUND

There are a number of requirements for the successful development, design and implementation of projects, programs and strategies. For example, it is important that the existing situation be thoroughly analyzed, that a logical hierarchy of the means for achieving objectives is established, that potential risks to achieving objectives and sustainable outcomes are identified, that the means for monitoring and evaluating outputs and outcomes be established, that a summary of the project is presented in a standard format, and that the project is monitored and reviewed during implementation. Promoting stakeholder participation and facilitating communication is equally important. This means that planners and managers need a suitable tool for the analysis, presentation and management of interventions/initiatives at different levels (project, program and strategy level).

9.2. DESCRIPTION

9.2.1 Background and use

Logical Framework Analysis (LFA, also known as the Logical Framework Approach or Logframe approach) originated in private sector management theory – together with other well-known approaches such as "management by objectives" – and dates back to the 1960s. It was first formally adopted as a planning tool by USAID for overseas development activities in the 1970s. It has since been used by a number of other development agencies such as British DFID, Canada's CIDA, the OECD Expert Group on Aid Evaluation, the International Service for National Agricultural Research (ISNAR), Australia's AusAID and Germany's GTZ (AusAID, p. 2).

LFA is an analytical, presentational and management tool capable of assisting planners and managers in accomplishing the following in the case of planned interventions/initiatives (AusAID, p. 1):

- **analyze the existing situation during project preparation;**
- **establish a logical hierarchy of means by which objectives will be reached;**
- **identify potential risks;**
- **establish how outputs and outcomes might best be monitored and evaluated;**
- **present a summary of the project in a standard format; and**
- **monitor and review projects during implementation.**

It is important to distinguish between the Logical Framework Approach and the Logical Framework Matrix. These concepts are defined as follows: "The *approach* involves problem analysis, stakeholder analysis, developing a hierarchy of objectives and selecting a preferred implementation strategy. The product of this analytical approach is the *matrix* (the Logframe), which summarizes what the project intends to do and how, what the key assumptions are, and how outputs and outcomes will be monitored and evaluated" (AusAID, p. 1).

These concepts are described in more detail in the sections below.

9.2.2 Situational analysis

As pointed out above, a structured analysis should precede the preparation of the Logframe matrix. This analysis involves a number of main analytical elements as outlined below.

Problem analysis

This element aims at identifying the *root causes* (as opposed to symptoms of the problem) to be addressed by the problem as well as the cause and effects relationship between them. Regarding the "problem tree", which is an important tool in problem analysis, two approaches can be used, namely the "focal problem method" or the "objectives oriented method" (AusAID, pp. 4-6).

Stakeholder analysis

Following the analysis of the problem, the stakeholder analysis focuses on identifying persons suffering most from identified problems, as well as the roles and interests of persons involved in addressing problems and reaching solutions. This analysis is important to better address distributional and social impacts of interventions, as well as a potential conflict of interests and mitigation strategies (AusAID, pp. 6-11).

Objectives analysis

"Objective trees", similar to a problem tree and using a similar structure, should be prepared as part of this step. "While the problem tree shows the *cause and effect* relationship between problems, the objective tree shows the *means* – *end* relationship between objectives. This leads directly into developing the project's narrative description in the Logical Framework Matrix" (AusAID, p. 11).

Identification of risks

This involves the identification of external factors, i.e. factors outside the direct control of project managers but which potentially can jeopardize the success of the project and should be managed accordingly (AusAID, pp. 23-25).

Analysis of alternative strategies

This involves a further and more formal exploration of the potential merits as well as difficulties and risks associated with the each of the different interventions, as revealed by the preceding steps (AusAID, pp 11-12).

9.2.3 The Logframe matrix

This matrix, which constitutes a project summary in terms of set parameters, has four columns and four or five rows (depending on the number of levels of objectives needed to explain the means-end relationship of the project). A distinction is made between two types of logic: "The *vertical logic* identifies what the project intends to do, clarifies the causal relationships, and specifies the important assumptions and uncertainties beyond the project manager's control (columns 1 and 4). The *horizontal logic* defines how project objectives specified in the project description will be measured, and the means by which the measurement will be verified (columns 2 and 3). This provides the framework for project monitoring and evaluation" (AusAID, p. 17).

The matrix structure is described in the box below, together with a brief description of the elements of the matrix.

LOGFRAME MATRIX STRUCTURE (AUSAID)			
Project Description	**Performance Indicators**	**Means of Verification**	**Assumptions**
Goal: The broader development impact to which the project contributes - at a national and sectoral level.	Measures of the extent to which a contribution to the goal has been made. Used during evaluation.	Sources of Information and methods used to collect and report it.	
Purpose: The development outcome expected at the end of the project. All components will contribute to this.	Conditions at the end of the project indicating that the purpose has been achieved. Used for project completion and evaluation.	Sources of Information and methods used to collect and report it.	Assumptions concerning the purpose/goal linkage.
Component Objectives: The expected outcome of producing each component's outputs.	Measures of the extent to which component objectives have been achieved. Used curing review and evaluation.	Sources of Information and methods used to collect and report it.	Assumptions concerning the component objective/purpose linkage.
Outputs: The direct measurable results (goods and services) of the project which are largely under project management's control.	Measures of the quantity and quality of outputs and the timing of their delivery. Used during monitoring and review,	Sources of Information and methods used to collect and report it.	Assumptions concerning the output/component objective linkage.
Activities: The tasks carried out to implement the project and deliver the identified outputs.	Implementation/work program targets. Used during monitoring.	Sources of Information and methods used to collect and report it.	Assumptions concerning the activity/output linkage.

9.3. EXPECTED RESULTS AND OUTCOME

The planning, design, implementation and monitoring of successful interventions at different levels (project, program and strategy level) require sound processes to be in place. LFA meets this need by providing a standardized, structured and generic set of tools for this purpose, recognizing the importance of stakeholder participation and effective communication.

9.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Needs assessment requires that the analyses, presentation and management of interventions at all levels (namely the project, program and strategy level) are based on sound and appropriate techniques. By providing a generic set of tools for planning, designing, implementing and evaluating any type of project, LFA enables road authorities to undertake these activities in a manner that is internationally accepted and used.

9.5. FACTORS AFFECTING APPLICATION

LFA has its critics and it should not be regarded as the alpha and omega in identifying and designing "good" programs and projects – in spite of its potential advantages. Nevertheless, it is important to adopt a balanced view of LFA. The box below highlights some of the potential strengths and weaknesses of LFA, as well as common problems that may be experienced and dangers that may be encountered in applying LFA.

STRENGTHS AND WEAKNESSES OF LFA (AUSAID)			
Issue	**Potential Strengths**	**Common Problems**	**Possible Dangers**
Vertical Logic	Provides logical link between means and ends. Places activity within broader development environment. Encourages examination of risks.	Getting consensus on objectives. Reducing objectives to a simple linear chain. Inappropriate level of detail (too much or too little).	Oversimplification of objective. Objectives become too rigid (blueprint). Ignoring unintended effects. Hides disagreements.
Horizontal Logic	Requires analysis of whether objectives are measurable. Helps establish monitoring and evaluation framework.	Finding measurable indicators for higher level objectives and 'social' projects. Establishing unrealistic targets too early.	Downgrading of less quantified objectives. Rigid targets. Information overload.
Format and Application	Links problem analysis to objective setting. Visually accessible and relatively easy to understand. Can be applied in a participatory way.	Prepared too late and mechanistically. Problem analysis and objective setting not always linked. Risks marginalized. High demands for training and judgment.	The same fixed format applied in all cases. Used for top-down control. Can alienate staff. Becomes a fetish rather than a help.

A number of websites may be consulted for more information on LFA, but the website of AusAID, the institution responsible for the document used in this section, is as follows:

www.ausaid.gov.au

NATA New Approach to Transport Appraisal

To be defendable, the appraisal process requires that impacts are summarized in a consistent manner and that the process itself is systemized. In this way, decision makers will be provided with a more transparent basis for project selection. NATA does this by focusing on the extent to which interventions are aligned with national transport objectives – for the UK, these impacts relate to the environment, safety, the economy, accessibility and integration (with other policy objectives). Results are summarized on a one-page Appraisal Summary Table. Other outputs of the NATA process are, firstly, an analysis of the achievement of regional and local objectives, secondly, an analysis of the effectiveness of problem solving (i.e. from a technical perspective), and, finally, supporting analyses, including distribution and equity issues, affordability and financial sustainability, and practicality and public acceptability. In doing this, NATA ensures investment decisions that are best aligned with decision criteria, including policy objectives at the national, regional and local level.

10. NATA: New Approach to Transport Appraisal

10.1. BACKGROUND

The impacts of interventions in transport infrastructure are wide and varied. It is important that all likely impacts resulting from the planned investment in transport infrastructure are identified and quantified, and included in the appraisal process. In particular, the appraisal process, to be defendable, requires that impacts are summarized in a consistent manner and that the process itself is systemized, in order to provide decision-makers with a more transparent basis for project selection.

10.2. DESCRIPTION

The New Approach to Transport Appraisal (NATA), developed in the United Kingdom by the Department for Transport, aims to facilitate project selection and decision-making in the public sector by providing a system for summarizing impacts and systemizing the overall process.

The five objectives for transport in the UK are listed in the box below.

FIVE OBJECTIVES FOR TRANSPORT AS OUTLINED IN THE WHITE PAPER
(UK DEPARTMENT FOR TRANSPORT WEBSITE)

- *Environmental impact:* This involves reducing the direct and indirect impacts of transport facilities on the environment of both users and non-users. There are 10 sub-objectives including noise, atmospheric pollution of differing kinds, and impacts on the countryside, wildlife, ancient monuments and historic buildings.
- *Safety:* This is concerned with reducing the loss of life, injuries and damage to property resulting from transport incidents and crime. The 2 sub-objectives are to reduce accidents and improve security.
- *Economy:* This is concerned with improving the economic efficiency of transport. The 5 sub-objectives are to improve economic efficiency for consumers and for business users and providers of transport, to improve reliability and the wider economic impacts, and to get good value for public money.
- *Accessibility:* This is concerned with the ability with which people can reach different locations and facilities by different modes.
- *Integration:* This aims to ensure that all decisions are taken in the context of the Government's integrated transport policy.

Compliance with these objectives is ensured by including them in the appraisal process which, in its turn, constitutes one of the steps of the transport study. These steps are the following (UK Department for Transport website):

- ***Agreement* on a set of project-specific objectives which the solution should seek to satisfy, these likely to be a subset of the Government objectives outlined above.**
- ***Analysis* of present and future problems on, or relating to, the transport system.**
- ***Exploration* of potential solutions for solving the problems and meeting the objectives.**
- ***Appraisal* of potential solutions, seeking combinations which perform better as a whole than the sum of the individual components**.
- ***Selection* and phasing of the preferred solution, taking account of the views of the public and transport providers**.

10.3 EXPECTED RESULTS AND OUTCOME

The appraisal output of NATA constitutes four parts:

- **Appraisal Summary Table (achievement of Government objectives).**
- **Achievement of regional and local objectives.**
- **Effectiveness of problem solving.**
- **Supporting analyses.**

Each of these components is explained in the boxes below.

NATA APPRAISAL OUTPUT 1: APPRAISAL SUMMARY TABLE

This is a one page summary of the impacts of a transport solution on the Government's objectives for transport.

An Appraisal Summary Table (AST) is produced for each solution considered and sets out the consequences of different solutions using the five objectives. Some of these objectives have been divided into a number of sub-objectives as described earlier, reflecting the wide variety of impacts arising from transport projects.

It is from this AST that a judgment would be made about the overall value for money of the option in achieving the Government's objectives. The information in the AST will enable a consistent view to be taken about the value of the project.

It is not intended that the AST will itself be sufficient for decision-making. It does not provide a complete picture, with important factors covered by other strands in the appraisal process.

NATA APPRAISAL OUTPUT 2: ACHIEVEMENT OF REGIONAL AND LOCAL OBJECTIVES

As part of the process, specific regional and local objectives will be set. These will reflect at least some of the Government's five objectives for transport, but will be more detailed and specific to the area being considered.

These objectives will be specific to each area, so there is no requirement for them to be the same in all appraisals. It is likely that local indicators or targets will be set against which to measure the performance of solutions.

The results of this analysis should be summarized in a form similar to the AST, showing how each option has fared against particular regional and local objectives.

NATA APPRAISAL OUTPUT 3: EFFECTIVENESS OF PROBLEM SOLVING

At an early stage in the process, the current and future transport related problems will have been identified. An assessment of the extent to which the problems identified would be solved by the option proposed needs to be made considering both absolute and relative performance against key indicators. By their nature these objectives are likely to be closely related the regional and local objectives, however further sub-objectives may be required to reflect the specific nature of the problem being considered.

It is usual to show the problem solving results on a map base, summarizing the problem identified and the effectiveness of the option against the indicators chosen.

NATA APPRAISAL OUTPUT 4: SUPPORTING ANALYSES

Supporting analyses cover three additional groups of issues:

- Distribution and equity which shows the distribution (by area, across modes, etc.) of the impacts of the solution.
- Affordability and financial sustainability shows the funding, etc. of the solution identifying public and private sector input.
- Practicality and public acceptability which follows a checklist to provide assessments (these include measures of feasibility, area of interest, complexity, time scale, phasing, political nature of solution).

The format of the AST is depicted in the table below. From this table it is clear that “means of assessment” constitutes a mixture of quantitative and qualitative measures. It therefore follows that the AST does not automatically provide a mechanistic way of expressing “project worth”, but rather serves to summarize impacts in a consistent manner so that decision makers have a more transparent basis for making a judgment.

OUTLINE OF THE APPRAISAL SUMMARY TABLE

Objective	Sub-Objective	Means of Assessment
Environment	Noise	Net Properties win/lose
	Local air quality	Concentrations weighted for exposure
	Greenhouse gasses	Tons of CO_2
	Landscape	Score
	Townscape	Score
	Heritage of historic resources	Score
	Biodiversity	Score
	Water environment	Score
	Physical fitness	Score
	Journey ambience	Score
Safety	Accidents	Present value of benefits £m
	Security	Score
Economy	Transport economic efficiency	Net present value £m
	Reliability	Score
	Wider economic impacts	Score
Accessibility	Option values	Present value of benefits £m
	Severance	Score
	Access to transport system	Score
Integration	Transport interchange	Score
	Land-use policy	Score
	Other Government policies	Score

Source: UK Department for Transport website

By systemizing the appraisal process through focusing on the extent to which each option contributes towards the achievement of national, regional and local objectives, as well as the effectiveness of problem solving and supporting analyses, NATA ensures investment decisions that are optimally aligned with policy objectives at national, regional and local level.

10.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Needs assessment and the appraisal and ranking of investment options require that all impacts of the project must be considered in project analysis and ranking. Furthermore, it requires project appraisal to be conducted in terms of a logical framework. Since NATA facilitates the appraisal process by systematically focusing on the extent to which options contribute to the achievement of national, regional and local objectives, the effectiveness of problem solving as well as the results of supporting analyses, it ensures that interventions in transport infrastructure are optimally aligned with the whole spectrum of decision criteria.

10.5. FACTORS AFFECTING APPLICATION

Since its original launch in 1998, NATA has been used in a number of applications in the UK. Examples includes the following:

- **Appraisal of multi-modal studies**
- **Appraisal of highways Agency road schemes and Local Transport Plans major road and public transport schemes**
- **The Strategic Rail Authority's Appraisal Criteria**
- **The project appraisal framework for seaports**
- **The appraisal process employed during the development of the Government's airports strategy**

However, factors limiting its use stem from the large amount of "performance data" to be collected for each project, and the difficulty in deriving at a single "score" for each project. This also affects the cost associated with the use of NATA.

Further information on NATA can be obtained from the UK Department for Transport website:

www.dft.gov.uk/

PAM Performance Assessment Model

STAKEHOLDERS REQUIRE CONCRETE evidence of the importance of their continued support for road maintenance initiatives. PAM was developed for this purpose: it is a simple, network-level macro evaluation tool that demonstrates the importance of the road sector in the economy, assesses the performance of road maintenance systems, and provides indicative figures of the consequences of budget constraints for road infrastructure. It uses country-specific relationships between maintenance spending and road condition, and between road condition and VOC, to determine the optimum level of road maintenance funding for 12 different cases (combinations of road and pavement types). "Optimum level of maintenance funding" is defined as that funding level where total transport cost, consisting of road user cost and road agency cost, is minimized. PAM also quantifies the cost to the economy of under-funding (i.e. of the "funding gap"); alternatively, it determines the benefit to the economy of increased maintenance spending.

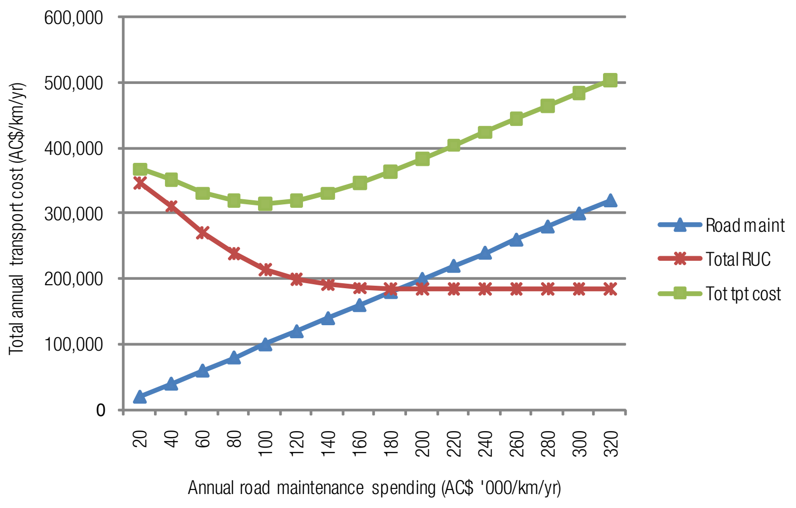
11. PAM: Performance Assessment Model

11.1. BACKGROUND

Stakeholders require concrete evidence of the importance of their continued support for road maintenance initiatives. In particular, they need indicative figures of the consequences of budget constraints to the road agency, the road user and the economy. This requires the use of country-specific relationships, in particular the relationship between road maintenance expenditure and road condition or between road condition and road user charges (RUC), in order to determine the optimum funding levels for different road and pavement types and to quantify the total transport cost for specified scenarios.

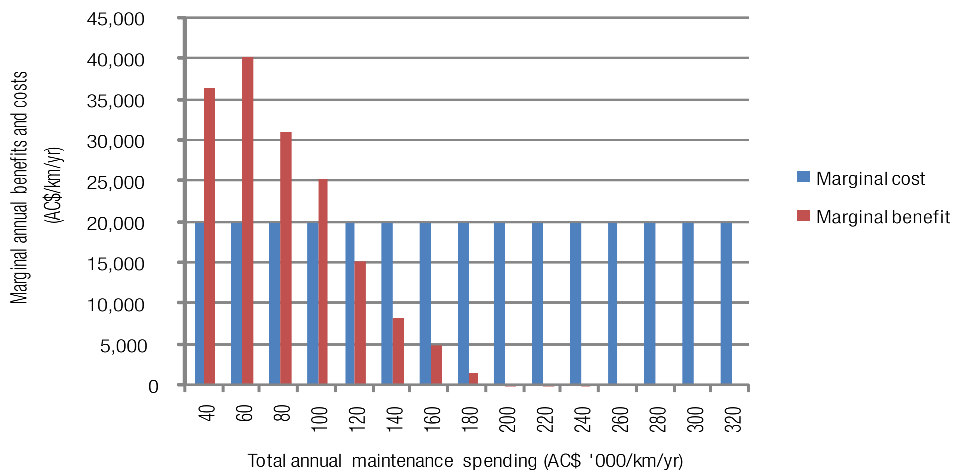
The figure below illustrates these relationships in the case of a hypothetical 1 kilometer section of road with an average daily traffic (ADT) of 150. The figure uses universally applicable relationships, and the currency is given as AC$ (any country $). For application to a specific country, therefore, these relationships must be customized first. The figure shows that, as spending on road maintenance increases (and given the consequent improvement in road surface condition), RUC (of which VOC constitutes about 90 percent) decreases until the optimal funding level (where total annual transport cost is minimized) is reached. However, the continued increase in road maintenance spending will gradually have a smaller impact on RUC as the negative impact of road surface condition on VOC decreases. This means that, after the optimal funding level is reached, total transport cost will start to increase again, and further increases in maintenance spending will be meaningless. From the figure it is also clear that, below the optimal funding level, additional costs will be for the account of the road user, mainly in the form of increased VOC. Beyond this point, additional costs will be for the account of the road authority in the form of additional (and wasted) road maintenance cost. The typical situation however is the "below optimum point" funding levels, which means that the road user is normally paying the price of inefficiencies in road infrastructure. Whoever bears this additional (wasted) cost, the point is that, ultimately it is the community at large that bears the brunt in the form of wasted total transport cost.

TOTAL ANNUAL TRANSPORT COST AS A FUNCTION OF ANNUAL ROAD MAINTENANCE SPENDING FOR ADT=150



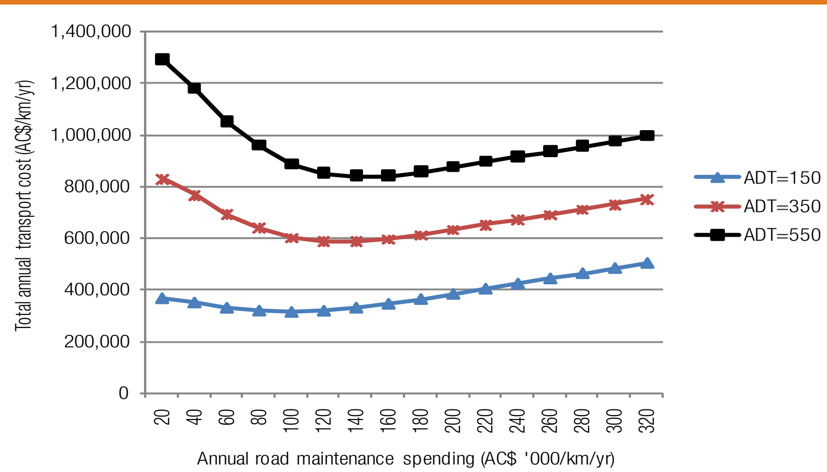
The optimal funding level can also be defined as that funding level where marginal (incremental) benefits equal marginal costs. For this purpose, marginal costs are defined as additional increments of road maintenance spending. Marginal benefits are defined as the resultant savings in RUC. The figure below shows that the optimal funding level in this case will be between an annual maintenance spending of AC$ 100 and AC$ 200, i.e. the situation where marginal benefits become smaller that marginal costs. Both the figures above and below thus indicate an identical optimum funding level.

COMPARISON OF MARGINAL BENEFITS AND COSTS FOR ADT=150



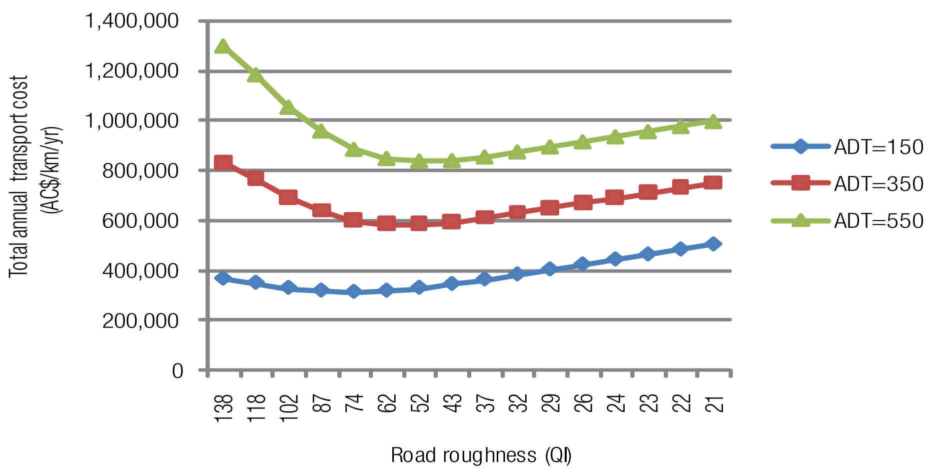
The optimum funding level is also dependent on the level of utilization of the road network. Using the same relationships as above, the figure below shows optimal funding levels for roads with different ADTs. From this figure, it is clear that, as ADT increases, the optimum funding level increases and that a higher service level is warranted.

TOTAL ANNUAL TRANSPORT COST AS A FUNCTION OF ANNUAL ROAD MAINTENANCE SPENDING FOR DIFFERENT ADTS



In the figure below, the same cost curves as used in the figure above are plotted as a function of road condition (expressed as road roughness), using the relationship between maintenance spending and road surface condition. In the case of ADT=550, the figure indicates an optimum funding level that translates into a road condition that can be regarded as very good (i.e. a level where additional maintenance spending will have little if no impact on RUC). In the case of ADT=150, on the other hand, it will be justified to adopt lower maintenance standards than in the case of ADT=550, as indicated by the optimal funding level. In summary, therefore, and considering the relationship between maintenance spending and level of service, it follows that a higher traffic demand would justify a higher level of service for the network. A different maintenance strategy would therefore be appropriate than in the case of lower level of demand. The optimum network (or maintenance strategy) therefore is dependent on the intensity of use of the network.

TOTAL ANNUAL TRANSPORT COST AS A FUNCTION OF ROAD ROUGHNESS FOR DIFFERENT ADTS



It is clear that there is a need for a tool that can accommodate these country-specific relationships to determine optimal country-specific maintenance strategies.

11.2. DESCRIPTION

PAM was developed by the SSATP as a tool for assessing the performance of road maintenance systems and the relative importance of the road sector in the economy, in order to demonstrate to stakeholders the importance of continued support for road maintenance initiatives. Using country-specific relationships between maintenance spending and road condition, and between road condition and VOC, it determines the minimum cost for sustaining the road network in its current (or desirable) condition. It also shows savings to the economy (in the form of savings in VOC) to be obtained from maintaining the network at "higher" levels. It further determines the optimum network, defined as that network (maintenance strategy) where total cost will be minimized. Finally, it determines the "funding gap", defined as the difference between current maintenance spending and required maintenance spending (to maintain the network at its optimum level), and the effect of under-spending on increased transport cost (VOC).

PAM makes provision for four road types (trunk, national, district and unclassified) and three pavement types (paved, gravel and earth), resulting in 12 options. It uses many of the road condition data and the VOC relationships contained in the Roads Economic Decision (RED) Model.

PAM was first applied in Tanzania, using Tanzania-specific data and cost relationships. A number of features were subsequently added or considered in its initial version. They include the following:

- **Improved user interface that requires only relevant data to be verified by the user**
- **Accommodation of differences in database structure between countries**
- **Additional analyses, e.g. to address "cross-subsidization" between trunk and feeder roads**
- **Restructured user interface to allow reconfiguration of PAM to the country in question**
- **Portuguese and French versions of PAM**
- **A multi-year analysis of the transition from the current road condition to the desirable level**
- **Socio-economic multipliers (generated from social accounting matrices) in order to generate estimates on direct and indirect impacts on poverty levels**

Data types used by PAM are described in the box below.

DATA TYPES IN PAM

(RMI, 2003, P. 1)

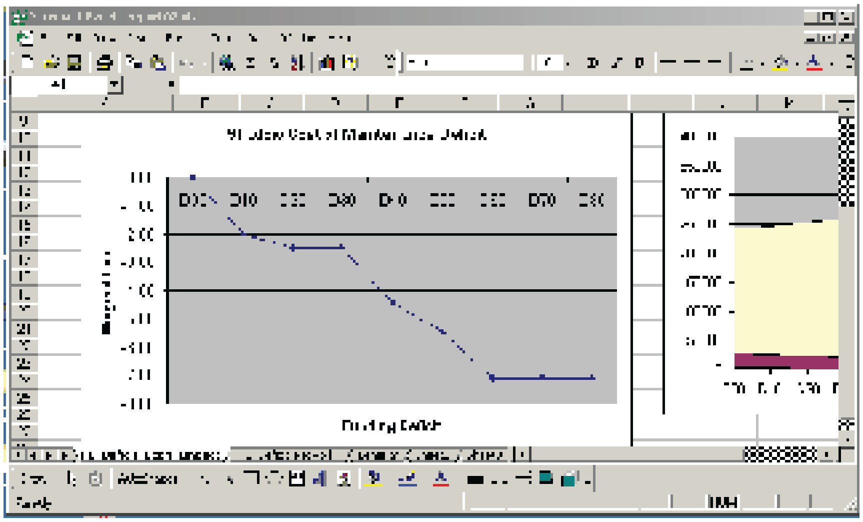
- *Road condition survey data:* The model is configured to the format of the available data of the country analyzed.
- *Design life of roads:* The design life time is specified in order to construct a simple mechanism that links road condition to periodic maintenance, improvement of road condition and extended lifetime of the investments. This simple mechanism is not dependent on traffic levels and has been agreed by the RMI coordinators.
- *Routine maintenance costs:* Unit maintenance costs are defined depending on the type and condition of roads. Total costs are the product of unit maintenance costs per the length of the roads in each class.
- *Periodic maintenance costs:* Unit periodic maintenance costs are defined depending on the type of roads and their condition before and after maintenance.

- *Vehicle operating costs:* The VOC data are entered as costs per kilometer weighed together by the traffic composition in order to assess the cost differences for road users per kilometer of road under changing road condition. These data can be calculated using the HDM or RED models.
- *Traffic levels/demand data:* Traffic volumes on the different types of roads in the network are the result of traffic counts or, when unavailable, by care estimate. These data are utilized in the assessment of the impact on the road users of the improvement/deterioration of the condition of the roads in the network as a whole.

11.3. EXPECTED RESULTS AND OUTCOME

The screen dumps below are examples of PAM outputs. The first figure shows the relationship between the "maintenance deficit" and "marginal VOC" (in the case of Rwanda). "Maintenance deficit" is shown for the range D00 to D80, where D80, for example, resembles an 80 percent deficit. In the case of D30, for example, it shows that a 30 percent funding deficit would increase VOC by US$2.50 for each US$1 saved on maintenance. Likewise, D50 shows that a funding deficit of 50 percent would increase VOC by US$5.50 for every US$1 saved on maintenance.

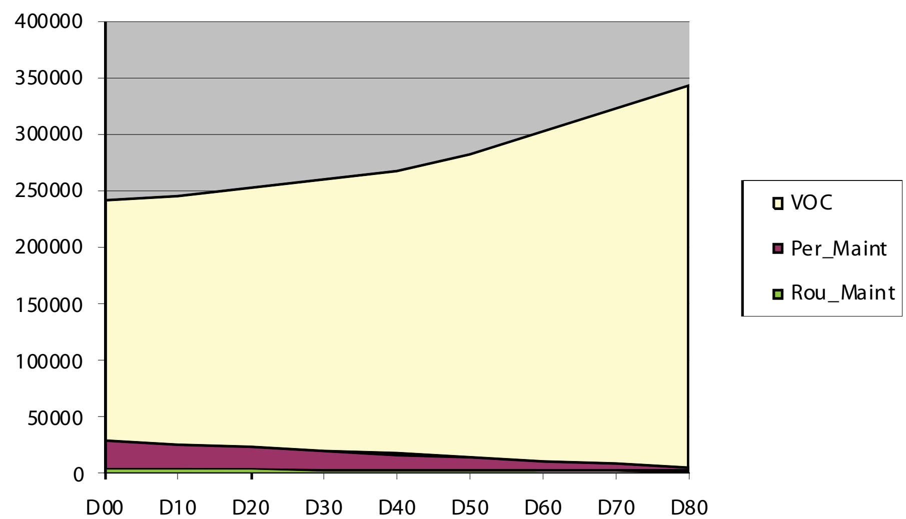
RELATIONSHIP BETWEEN MAINTENANCE DEFICIT AND MARGINAL VOC (IN THE CASE OF RWANDA)



Source: RMI, 2003, p. 19

The second figure (below) shows the relative magnitudes of VOC, periodic maintenance (including renewal) and routine maintenance costs as a function of funding deficit (again expressed as D00 to D80). From this figure it is clear that a small saving in maintenance cost (both routine and periodic maintenance) results in a more than proportional increase in VOC (and thus total cost), especially as "Maintenance deficit" increases beyond D40 and D50.

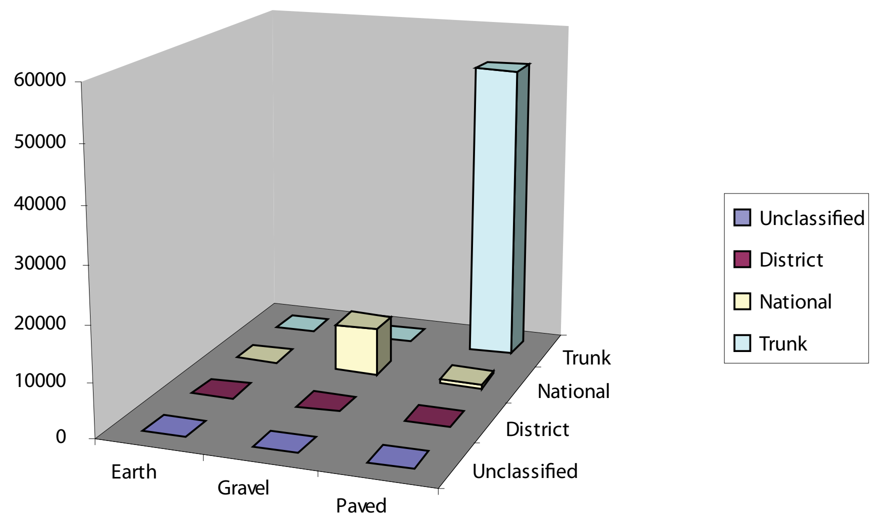
RELATIVE MAGNITUDE OF VOC, PERIODIC AND ROUTINE MAINTENANCE AS A FUNCTION OF FUNDING DEFICIT



Source: RMI, 2003, p. 19

Finally, the graph below summarizes potential benefits to be derived from improving the maintenance condition of the network from the *current* to the *desirable* condition in the case of Rwanda. It shows that there are considerable benefits (in the form of savings in VOC) to be obtained from improving the maintenance condition of the *paved trunk roads* and the *national gravel roads*. In the case of the district and unclassified road networks, it shows that, because of low traffic levels, savings in VOC are insufficient to justify upgrading to the *improved maintenance* condition.

BENEFITS TO BE DERIVED FROM IMPROVING THE MAINTENANCE CONDITION



Source: RMI, 2003, p. 19

PAM therefore quantifies the costs and benefits incidental to the *existing* and the *desirable* networks, as well as the resulting "funding gap" (i.e. the difference between actual and required funding levels for maintenance). By doing this, PAM enables road agencies to motivate for sufficient funding for road maintenance for different types of road, in order to minimize total transport cost to the community.

11.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Road sector policies formulation and network needs assessment require relevant country-specific relationships to be available. As PAM assesses the performance of road maintenance strategies and quantifies costs and benefits incidental to both the actual and the desirable funding level, as well as the "cost" of the "funding gap" (i.e. the difference between actual and desired funding levels for road maintenance), it enables road agencies to adopt appropriate policies and to motivate for additional funding for road maintenance where applicable in order to minimize total transport cost to the community.

11.5. FACTORS AFFECTING APPLICATION

PAM has been customized for 11 countries, Côte d'Ivoire, Ghana, Guinea, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe. Since a pavement and maintenance management system is required to provide the data needed for operating PAM, no major problems regarding its application are foreseen in cases where a reliable pavement and maintenance management system has already been set up and is being maintained. However, as PAM uses the cost relationships obtained from the RED model, calibration of the model for a specific country is required.

Because PAM is not a stand alone software that can be used on other countries without a country specific customization, the SSATP developed the Road Network Evaluation Tools (RONET), which incorporates the main features of PAM, to replace the functionality of PAM and facilitate its application on any developing country.

Further information can be found on the SSATP website by navigation to:

Road Management and Financing ⟶ Tools

PRA Participatory Rural Appraisal

ALL STAKEHOLDERS MUST BE INVOLVED in planning processes aimed at improving transport infrastructure and accessibility. This is particularly true in the case of poorer communities, as many planning processes focus on the needs of the richer members of society to the detriment of its poorer members. Generally, this implies a move to decentralized decision-making. PRA, which acknowledges this need, is described as "… a growing family of participatory approaches and methods that emphasize local knowledge and enable local people to make their own appraisal, analysis, and plans. PRA uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders" (World Bank Participation Sourcebook Appendix 1). PRA enables agencies to involve communities in a meaningful way and eliminate the perception that policies and plans are "forced" on them by "higher powers".

12. PRA: Participatory Rural Appraisal

12.1. BACKGROUND

In the context of development work, it is important that individuals, groups and communities in the lower income groups should be involved in processes and initiatives aimed at devising policies that address their needs. They should be given a voice and be given the opportunity to express themselves and their problems. This would provide policy makers with better insights in the issues to be addressed and ensure that policies are better fitted to the needs of the poor. It would also serve to challenge the perceptions of those in authority and, as a result, serve to change attitudes and agendas. In the past, however, this had not always been the case and, in some cases, policy was "forced" on communities by outside authorities. As a result, there is an increasing awareness that a more participatory approach is needed.

12.2. DESCRIPTION

Participatory Rural Appraisal (PRA) is described as "... a growing family of participatory approaches and methods that emphasize local knowledge and enable local people to make their own appraisal, analysis, and plans. PRA uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders. Although originally developed for use in rural areas, PRA has been employed successfully in a variety of settings. The purpose of PRA is to enable development practitioners, government officials, and local people to work together to plan context appropriate programs" (World Bank, 1996, Appendix 1, p. 1).

PRA uses a wide range of methods to enable people to express themselves and to share information. Visual methods include maps, flow diagrams, seasonal calendars and matrices or grids – all intended to stimulate discussion and analysis. PRA evolved from Rapid Rural Appraisal (RRA). The difference between PRA and RRA is that PRA aims at empowering local communities (e.g. by using local people to collect and analyze data), whereas RRA is seen as a set of informal techniques used by development practitioners to gather and analyze information about rural communities. Key tenets of PRA are listed in the box below.

KEY TENETS OF PRA

(WORLD BANK, 1996, APPENDIX 1, P. 2)

- *Participation:* Local people's input into PRA activities is essential to its value as a research and planning method and as a means for diffusing the participatory approach to development
- *Teamwork:* To the extent that the validity of PRA data relies on informal interaction and brainstorming among those involved, it is best done by a team that includes local people with perspective and knowledge of the area's conditions, traditions, and social structure and either nationals or expatriates with a complementary mix of disciplinary backgrounds and experience. A well-balanced team will represent the diversity of socioeconomic, cultural, gender, and generational perspectives.

- *Flexibility:* PRA does not provide blueprints for its practitioners. The combination of techniques that is appropriate in a particular development context will be determined by such variables as the size and skill mix of the PRA team, the time and resources available, and the topic and location of the work.
- *Optimal Ignorance:* To be efficient in terms of both time and money, PRA work intends to gather just enough information to make the necessary recommendations and decisions.
- *Triangulation:* PRA works with qualitative data. To ensure that information is valid and reliable, PRA teams follow the rule of thumb that at least three sources must be consulted or techniques must be used to investigate the same topics.

PRA is described as an exercise in communication and transfer of knowledge. PRA tools therefore involve a series of open meetings (initial meeting, final meeting, follow-up meeting), supplemented by other tools such as:

- **Semi-structured interviewing**
- **Focus group discussions**
- **Preference ranking**
- **Mapping and modeling**
- **Seasonal and historical diagramming**

Given this explanation of PRA, it follows that a PRA activity would typically involve a team of people working for two to three weeks on workshop discussions, analyses and fieldwork.

12.3. EXPECTED RESULTS AND OUTCOME

PRA is aimed at increasing stakeholder participation in the context of development initiatives. *Participation* is described as "… a process through which stakeholders influence and share control over development initiatives and the decisions and resources which affect them" (World Bank, 1996, Chapter 1, p. 1). *Stakeholders* include not only those persons to be affected (and to benefit) by development initiatives, but also "other" stakeholders which may include borrowers and indirectly affected groups. PRA, which has been described as a growing family of participatory approaches and methods emphasizing local knowledge and enabling local people to make their own appraisal, analysis, and plans, therefore enables road agencies to involve communities in a meaningful way and eliminate the perception that policies and planes are "forced" on them by "external powers".

12.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Network needs assessment and road expenditures programming require poor communities to be involved in initiatives affecting their lives. PRA, which can be described as a family of participatory approaches and methods that emphasize local knowledge and enable local people to make their own appraisal, analysis, and plans, enables agencies to involve communities in a meaningful way and to eliminate the perception that policies and plans are "forced" on them by higher/external powers.

12.5. FACTORS AFFECTING APPLICATION

12.5.1 Previous Applications

PRA has been used in almost every domain of development and community action in both urban and rural areas, such as:

- **Natural resources management**
- **Establishing land rights of indigenous people**
- **Slum development**
- **HIV/AIDS awareness and action**
- **Anti-poverty programs**
- **Disaster management**
- **Negotiation and conflict resolution**
- **Adult literacy**

PRA has also been used in six African countries, using different variants of PRA: "In Kenya and Tanzania, the approach included sampling a larger number of communities, using pre-designed scoring cards and categories, the aim being to produce statistically comparable results. In Ghana, Zambia, South Africa and Mozambique, fewer communities were covered but in more depth and with a more open-ended approach" (IDS, p. 4).

12.5.2 Limitations

The use of PRA may be limited by two factors. Firstly, there is a potential of abusing PRA. Secondly, its use can be expanded too quickly, as explained in the boxes below.

THE USE AND ABUSE OF PRA
(INSTITUTE OF DEVELOPMENT STUDIES, P. 2)

Unfortunately, there has been much abuse of PRA by outsiders keen only to extract information quickly, and use it for their own purposes. Such practice is unethical because local people are brought into a process in which expectations are raised, and then frustrated, if no action or follow-up results. To avoid this, those wishing to use PRA methods in a purely extractive way need to be transparent about their intentions, and refrain from calling what they do PRA.

In PRA, facilitators act as a catalyst, but it up to local people to decide what to do with the information and analysis they generate. Outsiders may choose to use PRA findings - for example, to influence policy or for research purposes. In all cases, however, there must be a commitment on the part of the facilitating organization to do its best to support, if requested to do so, the actions that local people have decided on.

DANGERS OF EXPANDING THE USE OF PRA TOO QUICKLY
(INSTITUTE OF DEVELOPMENT STUDIES, P. 5)

- Sudden scaling up risks discrediting PRA and alienating the local people who take part, especially if it involves introducing top-down, standardized, text book approaches—something that is contrary to the whole ethos of PRA;
- Since the attitudes and behavior of the outsiders facilitating PRA are so crucial, training to encourage and reward the right attitudes and behavior should be a central component in any scaling up effort;
- Attempts to incorporate PRA into development programs should start in pilot areas so that experience can be gained and opportunities be provided for learning and training;
- Scaling up needs to go hand-in-hand with the nurturing of local, community-based institutions, without which PRA cannot be firmly rooted in the longer term.

For more information on PRA, consult the World Bank Participation Sourcebook:

www.worldbank.org/wbi/sourcebook/sbxp08.htm ⟶ Appendix 1

RED Roads Economic Decision Model

TO JUSTIFY PROPOSED INVESTMENTS in transport infrastructure, the benefits and costs of proposed interventions must be quantified and compared. In the case of low volume unpaved roads, benefits often are different to those for primary (national) roads, where benefits typically are in the form of savings in vehicle operating cost and travel time cost. Examples of "other" benefits in the case of low volume roads are those associated with non-motorized traffic, social delivery and the environment. The low-volume unpaved road network is also much longer than the primary road network, meaning that the application of sophisticated methods for economic analysis, which normally require a high volume of input data, simply is not feasible as this would be extremely costly. RED has been developed to meet this need. It is a tool for economic analysis for unpaved roads with traffic levels higher than 30 vehicles per day. "RED is a consumer surplus model designed to help evaluate investments in low volume roads. The model is implemented in a series of Excel workbooks that: a) collect all user inputs; b) present the results in a user-friendly manner; c) estimate vehicle operating costs and speeds; d) perform an economic comparison of investments and maintenance alternatives; and e) perform sensitivity, switch-off values and stochastic risk analyses. The model computes benefits accruing to normal, generated, and diverted traffic, as a function of a reduction in vehicle operating and time costs. It also computes safety benefits, and model users can add other benefits (or costs) to the analysis, such as those related to non-motorized traffic, social service delivery and environmental impacts".

13. RED: Roads Economic Decision Model

13.1. BACKGROUND

It is important that investments in road infrastructure (involving new elements, the maintenance or upgrading of existing elements) can be economically justified, i.e. discounted benefits over the analysis period will be at least equal to discounted costs. Benefits associated with unpaved rural roads are however not limited to the reduction of vehicle operating cost and travel time, as often is the case on the national road network. The unpaved rural road network is also much longer than the primary road network, implying that the application of sophisticated methods for economic analysis, requiring a high volume of input data, would be extremely costly to the extent of rendering these methods unaffordable. Features of low-volume roads are listed in the box below.

CHARACTERISTICS OF LOW VOLUME ROADS
(ARCHONDO-CALLAO)

- High uncertainty of the assessment of traffic, road condition, and future maintenance of unpaved roads.
- Periods during a year with disrupted passability.
- Levels of service and corresponding road user costs defined not only through roughness.
- High potential to influence economic development.
- Beneficiaries other than motorized road users.

With reference to unpaved roads, it thus follows that there is a need for a tool to facilitate economic analysis at the project level, as well as for network strategic analysis under budget constraints.

13.2. DESCRIPTION

RED is an Excel model, developed by the SSATP in the late 1990s, to facilitate the economic analysis of low-volume roads in rural areas. The box below contains an overview of the model.

THE RED MODEL
(ARCHONDO-CALLAO)

RED is a consumer surplus model designed to help evaluate investments in low volume roads. The model is implemented in a series of Excel workbooks that: a) collect all user inputs; b) present the results in a user-friendly manner; c) estimate vehicle operating costs and speeds; d) perform an economic comparison of investments and maintenance alternatives; and e) perform sensitivity, switch-off values and stochastic risk analyses. The model computes benefits accruing to normal, generated, and diverted traffic, as a function of a reduction in vehicle operating and time costs. It also computes safety benefits, and model users can add other benefits (or costs) to the analysis, such as those related to non-motorized traffic, social service delivery and environmental impacts.

The RED model calculates benefits accruing to normal, generated and diverted traffic. Benefits calculated by the model are reduced vehicle operating cost and travel time cost, and increased safety. Users have the option to include other ("exogenous") impacts such as those associated with non-motorized traffic, social delivery and the environment. The table below lists the various Excel 5.0 workbooks that constitute the RED model.

EXCEL WORKBOOKS IN THE RED MODEL		
Workbook Filename	**RED Module**	**Purpose**
RED - Main (version 3.2). XLS.	Main Economic Evaluation Module	Perform the economic evaluation of one road
RED - HDM-III VOC (version 3.2).XLS	HDM-III Vehicle Operating Costs Module	Define the relationship between motorized vehicles operating costs and speeds to road roughness, for a particular country, using HDM-III relationships
RED - HDM-4 VOC (version 3.2).XLS	HDM-4 Vehicle Operating Costs Module	Define the relationship between motorized and non-motorized vehicles operating costs and speeds to road roughness, for a particular country, using HDM-4 relationships
RED - RISK (version 3.2). XLS	Risk Analysis Module	Perform risk analysis using triangular distributions for the main inputs
RED - Program (version 3.2).XLS	Program Evaluation Module	Program Evaluation Module Perform the economic evaluation of a network of roads sections or road classes

Important features of the RED model, as discussed in the accompanying documentation (Archondo-Callao), are as follows:

- **RED reduces the input requirements for low-volume roads.**
- **It takes into account the higher uncertainty related to the input requirements.**
- **It clearly states the assumptions made, particularly on the road condition assessment and the economic development forecast.**
- **It computes internally the generated traffic due to decrease in transport costs based on a defined price elasticity of demand.**

- **It quantifies the economic costs associated with the days per year when the passage of vehicles is further disrupted by a highly deteriorated road condition**.
- **It uses alternative parameters to road roughness to define the level of service of low volume roads.**
- **It allows for the consideration in the analysis of road safety improvements.**
- **It enables the inclusion in the analysis other impacts such as those associated with non-motorized traffic, social service delivery and the environment. These are however user-supplied and therefore constitute "exogenous" inputs to the model.**
- **It raises questions in different ways; for example, instead of asking what is the economic return of an investment, one could ask for the maximum economically justified investment for a proposed change in level of service, with additional investments being justified by other social impacts.**
- **It presents the results with the capability for sensitivity.**
- **It has the evaluation model on a spreadsheet, such as Excel, which is more user-friendly and capitalizes on built-in features and tools such as goal seek, scenarios, solver, data analysis, and additional analytical add-ins.**

Some of these features may however constitute limitations in the use of RED, as explained below.

13.3. EXPECTED RESULTS AND OUTCOME

Examples of RED outputs are given below. These outputs enable road agencies to make investment decisions that are economically feasible and which, as a result, will reduce total transport cost to the community:

- **A detailed economic feasibility report for each project option, including assumptions, computed vehicle speeds, travel times, generated traffic, streams of net benefits and economic indicators.**
- **A user impacts report given more detailed results such as the percentage reduction of economic road user cost per vehicle class.**
- **A sensitivity analysis for 18 data input types.**
- **A switching analysis, indicating for each of the 18 main input data types when the net present value will be equal to 0 (i.e. at which input value the project changes from justified to not justified).**
- **A risk analysis, using a Monte Carlo simulation, producing risk frequency distributions.**

13.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

RED has been designed as an analysis tool in the case of unpaved roads with traffic levels higher than 30 vehicles per day. RED is not only suited for analysis at the project level, but it can also perform network strategic analysis under budget constraints. As such, it can contribute to a number of management functions, e.g. road network policies formulation, network needs assessment, road expenditures programming, and the preparation on road projects.

13.5. FACTORS AFFECTING APPLICATION

Although the RED model, which is provided free of charge by the SSATP, has been used in a number of countries in the region, some of its features (discussed above) may impact on the reliability of its results. For example, the fact that the user himself has to enter the anticipated roughness after the works are executed (e.g. treatment of hot spots) constitutes a big uncertainty in itself. Likewise, the roughness is taken as constant during the study period, given the assumption that maintenance will be sufficient to sustain roughness. Alternatively, the user must enter anticipated speed (instead of roughness) for the "after project" situation. All these assumptions may contribute to some degree of uncertainty in respect of the results of the model.

Regarding data requirements, SSATP Technical Note no 18, claims that "RED is easy to use and requires limited number of input data requirements consistent with the level of data likely to be available for the analysis of low-volume roads in developing countries". It is nevertheless necessary that the model be calibrated for a given country, and to this end users are required to provide basic data on the unique features of the vehicle fleet of the given country.

The tool itself can be found on the SSATP website:

www.worldbank.org/afr/ssatp ⟶ Road Management and Financing ⟶ Tools

RONET
Road Network Evaluation Tools

RONET IS A MODEL WHICH could be used by decision makers to appreciate the current state of the road network, its relative importance to the economy (e.g. asset value as percentage of GDP) and to compute a set of monitoring indicators to assess the performance of the road network. RONET assesses the performance over time of the road network under different road maintenance standards and determines the optimal maintenance standard for each road class. Finally it determines the "funding gap," defined as the difference between current maintenance spending and required maintenance spending (to maintain the network at a given level of service), and the effect of under spending on increased transport costs. The Road User Charges Module estimates the level of road user charges required (e.g. fuel levy) to meet road maintenance expenditures under different budget scenarios. All this is done by combining country-specific (either default or user-supplied) data with selected (and simplified) relationships from HDM-4, e.g. the road user cost/road roughness relationship, the paved road roughness progression (deterioration) model, and the gravel roads gravel loss model. The primary audience of RONET is decision-makers in the road sector, for whom it is designed as a tool to advocate for continuous support for the road maintenance initiative.

14. RONET: Road Network Evaluation Tools

14.1. BACKGROUND

Simple operational road management systems are a prerequisite for articulating the consequences of road funding trends and policies to stakeholders in a robust manner. Road agencies and ministries have often failed to justify current funding levels to politicians and financiers, let alone winning the argument for more funds, by using complex models for this purpose. Although they may be more accurate, complex models (e.g. HDM-4) may alienate decision makers because of the complexity of their outputs.

RONET was developed by the SSATP to replace the functionality of the following tools (described in more detail in other chapters of this document):

- **The Road User Charges Model Version 3.03 (RUC), which evaluates scenarios of road user charges in a country, evaluating road classes in good and fair condition differentiated by traffic level, and estimating routine and periodic maintenance requirements derived from look-up solution tables. The RUC model represents the entire network of a country by a maximum of 160 road classes that are functions of traffic, percent of cars, trucks loading, pavement strength, environment, level of agency costs, and vehicle operating costs.**
- **The Performance Assessment Model Version 1.04 (PAM), which estimates the performance of a road network under different budget scenarios, evaluating road classes on any road condition but not differentiating the road classes by traffic level, and estimating routine and periodic maintenance requirements derived from a straight line deterioration model. The PAM model represents the entire network of a country by a maximum of 64 road classes that are functions of functional classification, pavement type, and condition (Archondo-Callao R., p. 2)**.

Its primary audience is decision-makers in the road sector, and it has been designed as a tool for the advocacy of specific revenue enhancing or cost recovery measures. RONET can be used for strategic planning of maintenance and rehabilitation road works, monitoring the performance of the network, to assess the consequences of budget constraints, and to compute the funding gap with relation to revenues collected from road user charges. It thus enables the rapid assessment of the effects of government funding decisions.

RONET is being developed as a Microsoft Office Excel 2003 workbook. Version 1.0 was released in July 2007, and Version 1.01 in October 2007. Version 2.00 will be released by December 2008. One of the important additions of Version 2.00 is the definition of the optimal standard per road class (defined by network type, surface type, traffic category and condition category) and the calculation of the resulting total network road agency costs, road user costs, society costs, net benefits and roughness weighted by kilometer, obtained from implementing the optimal standard per road class, defined as the standard that yields the lowest present value of society costs, at the input discount rate (Archondo-Callao R., 2007c, p. 1). RONET Version 2.00 has a new module that evaluates road user revenues collected from a series of instruments (for example, fuel levy, registration fees, tolls, international transit fees, etc.) and compares the revenues with the funding needs for maintenance and rehabilitation of the network.

14.2. DESCRIPTION

In addition to providing selected performance monitors of the network (in the Current Condition Assessment module), RONET answers the key question: **What is the cost to the economy and selected stakeholders of maintaining the network to the defined (current) standard as opposed to the optimum (desired) standard?** Given the ideal of an optimum standard: What would be the implications for various selected stakeholders? This is addressed in the Performance Assessment module (previously PAM). Ultimately, RONET will also have the functionality of the RUC tool, and, in addition, will be able to answer a number of other critical questions (see above for future improvements). All this is done by combining (processing) country-specific (either default or user-supplied) data with selected (simplified) relationships from the universally accepted HDM tool, e.g. the road user cost/road roughness relationship, the paved road roughness progression (deterioration) model, and the gravel roads gravel loss model.

A total of 625 road classes are available in RONET from different combinations of network type, surface type, traffic category and road condition category, as defined below. Road classes can be characterized further by terrain and climate type and geographical region.

Network types:

- **The default network types are as follows: Motorway, primary, secondary, tertiary, unclassified.**

Surface types:

- **Cement concrete pavement**
- **Asphalt mix pavement**
- **Surface treatment pavement**
- **Gravel road**
- **Earth road**

Traffic categories:

- **Traffic I, Traffic II, Traffic III, Traffic IV, Traffic V.**

Road condition categories: For paved roads, they are:

- ***Very good*: Roads in very good condition require no capital road works.**
- ***Good*: Roads in good condition are largely free of defects, requiring some minor maintenance works, such as preventive treatment or crack sealing.**
- ***Fair*: Roads in fair condition are roads with defects and weakened structural resistance, requiring resurfacing of the pavement (periodic maintenance), but without the need to demolish the existing pavement.**

- ***Poor***: **Roads in poor condition require rehabilitation (strengthening or partial reconstruction).**
- ***Very poor***: **Roads in very poor condition require full reconstruction, almost equivalent to new construction.**

Input data for RONET are entered under five main headings, as outlined in the box below.

RONET INPUT DATA (VERSION 2.0)

Country Data:

- Name and year (name of country, region or road agency, and date of data)
- Basic characteristics (land area, total population, rural population, GDP at current prices, total vehicle fleet, discount rate)
- Traffic growth and pavement width (annual traffic growth rate over the 20-year evaluation period and the average pavement width per network type)
- Capital road works unit costs (for both capital road works (periodic maintenance, rehabilitation and new construction) and recurrent maintenance works (annual works on carriageway, and annual works outside carriageway)
- Recurrent maintenance works unit costs (for each surface type, in US$ per kilometer per year for a two-lane road)
- Traffic levels characteristics (for each of the 9 traffic levels, the following: average, minimum, and maximum AADT, average traffic composition, and for each vehicle type: (i) equivalent standard axles (ESA per vehicle), (ii) average cargo payload per vehicle (tons per vehicle), and (iii) average number of passengers per vehicle (passengers per vehicle)
- Vehicle fleet unit road user costs relationship to roughness (define the coefficients of the cubic polynomial (relationship between unit road user costs and roughness for a particular country) for each traffic level, based on local conditions)
- Accident rates and costs

Road Network Data:

- Road network length distribution by network type, surface type, traffic category, and road condition category

Historical Data:

- Historical average road works expenditures during the last five years
- Historical average road works during last five years, in kilometer per year

Road user charges:

- Fuel consumption, vehicle fees, distance travel fees, international transit fees, tolls, etc.

Funding requirements:

- Maintenance and rehabilitation
- Investments
- Administration

14.3. EXPECTED RESULTS AND OUTCOME

At present, RONET has three output modules; the first summarizing the current situation, the second answering "what if" questions on the performance of the network under different budget scenarios, and the third evaluates road user charge.

Current Condition Assessment Module

This module evaluates the current network condition and presents summary network statistics and network monitoring indicators. The main output categories are listed in the box below. The last category (network monitoring indicators), is expanded further in the second box.

RONET OUTPUT: CURRENT CONDITION ASSESSMENT MODULE (VERSION 2.0)

Current Condition Assessment Overview:

- Length and utilization: presents the network length and network utilization distribution by network type and surface type
- Asset value: presents the network maximum asset value and network current asset value distribution by network type and surface type.
- Roughness: presents the average network roughness weighted by kilometer and the average network roughness weighted by vehicle-km by network type and surface type
- Network distribution charts: presents network distribution charts of the network length, utilization, and maximum and current asset value by network type and surface type
- Network monitoring Indicators: presents road network monitoring indicators

Length and Utilization:

- Total network length (km) and total network utilization (million vehicle-km) and the distribution by network type, surface type, surface class (paved or unpaved), road condition category, and traffic category

Asset Value:

- Total network *maximum* asset value and total network *current* asset value, and the distribution by network type, road type, road condition category, and traffic category

Roughness:

- Network average roughness weighted by kilometer, and network average roughness weighted by vehicle-km by network type, surface type, road condition category, and traffic category

Network Distribution Charts:

- Network distribution charts of the network length, utilization, and maximum and current asset value by network type and surface type

Network Monitoring Indicators:

- This page presents a road network monitoring indicators table for 6 categories and 2 user-defined charts – see the box below for a more detailed list of outputs

RONET OUTPUT: CURRENT CONDITION ASSESSMENT MODULE: NETWORK MONITORING INDICATORS (VERSION 2.0)

Network Length:

- Road network length (km)
- Road network length that is unpaved (km)
- Road network length that is paved (km)
- Road network length that is paved (%)

Network Density:

- Road network per thousand land area (km/1000 sq km)
- Road network per thousand total population (km/1000 persons)
- Road network per thousand rural population (km/1000 persons)
- Road network per thousand vehicles (km/1000 vehicles)
- Road network per US$ million GDP (km/million US$)
- Paved road network per thousand land area (km/1000 sq km)
- Paved road network per thousand total population (km/1000 persons)
- Paved road network per thousand rural population (km/1000 persons)
- Paved road network per thousand vehicles (km/1000 vehicles)
- Paved road network per US$ million GDP (km/million US$)

Network condition:

- Percentage of road network in good and fair condition (%)
- Percentage of paved road network in good and fair condition (%)
- Percentage of paved road network with roughness 4 m/km IRI or less (%)
- Paved roads average roughness weighted by kilometer (IRI, m/km)
- Paved roads average roughness weighted by vehicle-km (IRI, m/km)
- Percentage of unpaved roads that are all-weather roads (%)

Network Access:

- Percentage of unpaved roads that are all-weather roads (%)
- All-weather roads area of influence (4 km wide) as a share of per land area (%)

Network standards:

- Percentage of unpaved roads with 30 AADT or less (%)
- Percentage of unpaved roads with 300 AADT or more (%)
- Percentage of paved roads with 300 AADT or less (%)
- Percentage of paved roads with 10,000 AADT or more (%)

Network utilization:

- Annual motorized vehicle utilization (million vehicle-km)
- Annual freight carried over road network (million ton-km)
- Annual passengers carried over road network (million passenger-km)
- Average network annual average daily traffic (vehicles/day)

Network Safety:

- Annual number of fatalities (persons)
- Annual number of serious injuries (persons)
- Annual number of casualties (persons)
- Annual casualties cost (million US$)
- Annual casualties cost as a share of GDP (%)
- Annual number of fatalities per total population (#/100,000 persons)

Network asset value:

- Current road asset value (million US$)
- Current road asset value as a share of maximum road asset value (%)
- Current road asset value as a share of GDP (%)

Performance Assessment Module

This is the second output module of the current version. Its objective is to assess the consequences of applying different road works standards (which, in turn, imply different levels of road works expenditure). Consequences are considered for a 20-year period. They are explained in the box below. The eight options for "user-defined road works standards" for the purpose of this module are as follows:

- **Very high standard: This represents a scenario without budget constraints but with an optimal level of periodic maintenance and rehabilitation works.**
- **High, medium, low and very low standard: They represent scenarios of decreasing levels of road works expenditures.**
- **Do minimum standard: This represents a scenario where the only capital road work applied over the evaluation period is reconstruction, at a very high roughness.**
- **Do nothing standard: This represents a scenario where no capital road works are applied over the evaluation period.**
- **Custom standard: This is the standard (very high, high, medium, low, very low, do minimum or do nothing) that applies to each road network type.**

RONET OUTPUT: PERFORMANCE ASSESSMENT MODULE (VERSION 2.0)

Network performance:

Presents the consequences to the total, paved or unpaved network of applying the different road works standards for different budget scenarios. Consequences are presented in terms of:

- Road agency costs
- Society costs (total society costs, society net loss compared to very high standard and, society net benefits compared to do minimum standard (all of these over a 20-year period)
- Road user costs (e.g. impact of road agency deficit on road user costs)
- Network asset value
- Network roughness
- Network condition
- Annual road agency costs
- Annual road agency costs by GDP

Annual Work Program:

Presents for a given budget scenario the annual maintenance and rehabilitation needs, road user costs, total society costs, flow of net benefits, asset value, road works length, and average network roughness.

Road works distribution:

Presents, for a user-selected budget scenario, the distribution of the recurrent maintenance, periodic maintenance and rehabilitation costs, and road works length by network type, management type, surface type, and surface class, for years 1 to 5, 6 to 20 and 1 to 20. The output tables present: (i) total road works costs (M$); (ii) annual road works costs (M$/year); (iii) annual road works costs per km ($/km-year); (iv) annual road works costs per vehicle-km ($/vehicle-km-year), and (v) annual road works length (km/year).

Road works summary:

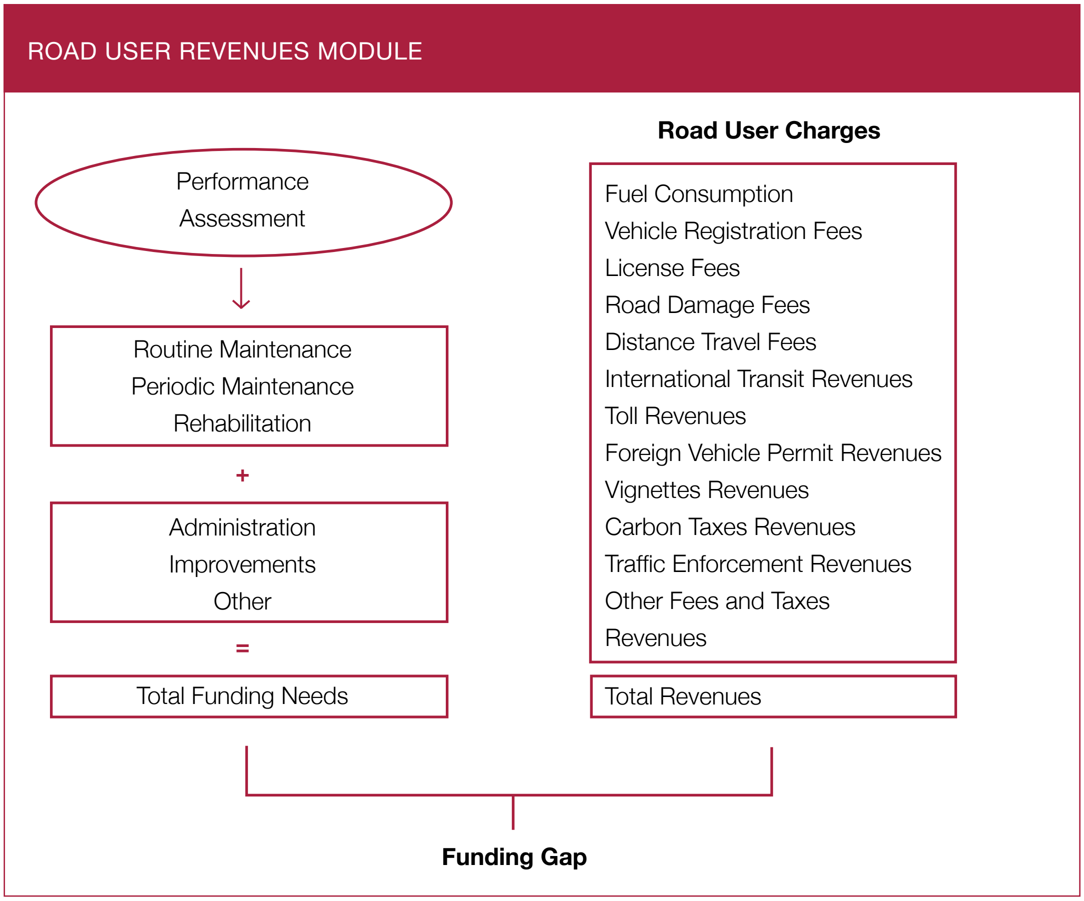
Presents for a user-selected standard, period (years 1 to 5, 6 to 20 or 1 to 20), and road work type (recurrent maintenance, periodic maintenance, rehabilitation, or all works), a summary of the distribution, by network type, management type and surface type, of the following: (i) road works costs; (ii) current network length, (iii) current network utilization; and (iv) current network asset value.

Historical data comparison:

Presents, for a user-selected standard, network type and road work type: (i) the historic expenditures over the last five years, (ii) the required expenditures over the next five years, and (iii) the ratio between the required per historic expenditures.

Road User Revenues Module

This is the third output module of the current version. Its objective is to assess the road user revenues collected from road user charges that can be assigned to the road sector (road fund) or to the general budget. The road user revenues are then compared with the funding requirements for maintenance, rehabilitation, investments, and administration. The figure below illustrates this module.



14.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Given the functionality of the current version, RONET will constitute a multi-faceted tool, combining the functionality of a variety of tools and making a corresponding multi-faceted contribution to road infrastructure management.

14.5. FACTORS AFFECTING APPLICATION

A number of "drawbacks" have been identified in the Uganda case study (Archondo-Callao, 2007b). It is believed that they may be of a general nature, applying to other countries as well. These "drawbacks" are listed below; it should however be borne in mind that some of them have already been taken care of in the current version of RONET and that others may be the focus of future improvements to RONET:

- **The summary or aggregate nature of the inputs to the model are susceptible to inaccuracies which can, in turn, distort the validity of outputs;**
- **Accurate traffic and condition data are not available especially for the secondary and tertiary networks making it necessary to make assumptions;**
- **The model does not yet carry out optimization of standards for budget of benefit maximization;**

- **Comprehensive sensitivity analysis has not yet been carried out to determine the impact elasticity of inputs for, say, maintenance standards; RUCKS outputs coefficients (currently based on paved roads); capital and recurrent costs for tertiary roads for which data is not usually available; etc.;**
- **The model does not yet model the impacts of overloading on network condition and agency requirements which is a very vital piece of information for road managers.**

The tool itself can be found on the SSATP website:

www.worldbank.org/afr/ssatp ⟶ Road Management and Financing ⟶ Tools

RUC Road User Charges Model

AN ECONOMIC THEORY REQUIRES CONSUMERS to bear the full cost of the relevant product or service they consume, in order to ensure the optimal and equitable allocation of scarce resources. In the case of road infrastructure, this principle/process is known as road user charging (RUC). The costs to be borne by beneficiaries of road transport – in addition to road user cost itself – are the cost of providing the road network, and external costs such as pollution, congestion and accident cost. RUC implies three steps, namely (a) road pricing, (b) road cost allocation, and (c) road cost recovery. The RUC model "... estimates road user charges required to ensure that, for a particular country, the costs of operating and maintaining all roads are fully-funded, and that each vehicle class covers its variable costs. The model is an Excel workbook that: (i) estimates annualized maintenance costs needed to maintain a stable road network; (ii) defines countrywide annual recurrent expenditures, annual investment needs, and source of financing; (iii) estimates road user revenues from annual license fees, fuel levies, load damage fees, and tolls; (iv) analyzes the allocation of road user revenues and optimizes road user charges; and (v) computes externalities and summary macro indicators".

15. RUC: Road User Charges Model

15.1. BACKGROUND

An economic theory requires consumers to bear the full cost of the product or service they consume, in order to ensure the optimal and equitable allocation of scarce resources. When this does not happen, the free market dynamics are distorted and a sub-optimal allocation of scarce resources will result, leading to the wastage of these resources. In the case of roads, this is known as road user charging (RUC) where road users (and all other beneficiaries of transport) must pay the full cost incidental to providing the road network. This comprises the cost of constructing, maintaining and managing the road network, as well external costs (consisting of pollution, congestion and accident cost).

RUC implies a number of steps. Firstly, all costs incidental to providing the network should be determined (i.e. *road pricing*). Two methods that could be used for road pricing are the historic cost method and the development cost method, as explained in the box below.

METHODS FOR ROAD PRICING

Historic cost method:

With this method, network cost is determined by considering costs already incurred in the existing network and including the cost of constructing and improving the network. This method therefore is based on the *historic or sunk* cost of the road network. The method firstly requires that network cost be quantified, and secondly that it be "spread out" over the economic life of the network (using an appropriate discount rate) in order to determine the cost per time unit.

Development cost method:

This method, also known as the current expense method, is based on the *current and future* cost of constructing, maintaining, expanding and improving the road network. Two methods can be used for this purpose:

- Long-term marginal cost method
- Incremental method

Secondly, costs should be allocated to different types of road users (e.g. different vehicle classes). This is known as *road cost allocation*. Finally, cost should be recouped from the different classes of road users, based on the "fair share" of each as determined through the process of road pricing and cost allocation, using appropriate tools. This is known as *road cost recovery*. These sources can be classified under five headings:

- **Tax relating to vehicle use**
- **Tax on vehicle ownership**

- **Tax on place of use**
- **Taxes imposed by local authorities**
- **General revenue sources**

Given the principle of road user charging, it is evident that there is a need for a tool that can assist road authorities in applying it, given the unique characteristics of the different elements of the network under their jurisdiction and their utilization. In addition to the benefits outlined above, such a tool will ensure that, for a particular country, the costs of operating and maintaining the network are fully funded and that each vehicle class covers its variable cost.

15.2. DESCRIPTION

The RUC model, developed by the SSATP, is described in the box below.

THE RUC MODEL
(SSATP WEBSITE)

The Road User Charges Model (RUC) estimates road user charges required to ensure that, for a particular country, the costs of operating and maintaining all roads are fully-funded, and that each vehicle class covers its variable costs. The model is an Excel workbook that: (i) estimates annualized maintenance costs needed to maintain a stable road network; (ii) defines countrywide annual recurrent expenditures, annual investments needs, and source of financing; (iii) estimates road user revenues from annual license fees, fuel levies, load damage fees, and tolls; (iv) analyzes the allocation of road user revenues and optimizes road user charges; and (v) computes externalities and summary macro indicators.

Specific objectives of the RUC model are as follows (Archondo-Callao, 2000):

- **Ensure that revenues from road user charges fully cover the costs of operating and maintaining the inter-urban and urban road networks.**
- **Ensure that all vehicle classes cover their attributable variable costs of road usage.**
- **Compare the funding needs of the country amongst the road networks (primary, secondary, urban, etc.)**.
- **Assess the distribution of revenues from road user charges among road networks administrations (main road agency, municipalities, etc.).**
- **Define gasoline and diesel levies needed to finance a road fund.**
- **Compute financing and revenues indicators.**
- **Estimate the magnitude of fuel emissions and other externalities.**

At the strategic level (and at least in theory), therefore, the RUC model will ensure the following strategic outcomes (Heggie and Archondo-Callao, p. 1):

- **The correct market signals are provided to road users.**
- **Road agency uses resources efficiently.**
- **The road network is constrained to the size and quality that is affordable (by indicating the size and quality that is affordable).**
- **Sufficient revenues are generated to operate and maintain the road network on a sustainable basis.**

It is also important to note some practical difficulties in adopting a short-run marginal cost (SRMC) approach, as outlined in the supporting documentation (Heggie and Archondo-Callao, 2000). In terms of the short-run marginal cost approach, road user charges should be equal to the costs of resources consumed when using the network. These costs are, firstly, the damage done to the road by the passage of vehicles, and secondly, the additional cost which road users impose on other road users and on the rest of society (i.e. externalities such as congestion cost). The problem arises from the fact that less than half the cost of operating and maintaining the network depends on traffic. The balance of cost can be regarded as a fixed cost, not dependent on use. This means that if costs are set equal to SRMC, financial deficits will result as insufficient funds will be collected from road users. The RUC model handles this by recovering all costs from road users, given the following arguments:

- **The welfare cost of collecting the required revenue from road users is lower than collecting it through general taxes**
- **Raising revenues from road users will have positive distributional effects as they generally come from the higher income groups in society**

User input involves data such as the following:

- **Network length of each road class (namely main roads, secondary roads, tertiary roads, and urban streets)**
- **Road maintenance cost**
- **Vehicle fleet: Up to 15 vehicle types can be accommodated. For each vehicle type, the following must be entered:**
  - **Vehicle type description**
  - **Vehicle class (motorcycle, private or commercial)**
  - **Fuel type (diesel, gasoline or alcohol)**
  - **Total number of vehicles using the road network**
  - **Average number of kilometers driven per year**

- **Average equivalent standard axles per vehicle (ESA per vehicle)**
- **Fuel consumption**

■ **Current overall user charges**

The table below shows the format of the input table for network length in the case of main roads. Each road class is further divided into different surface types, namely paved, gravel and earth roads. For each of these surface types, different options are specified such as “Traffic: 300 vpd – 30% Trucks/Loading: Low”, as shown in this table.

FORMAT OF INPUT TABLE FOR NETWORK LENGTH

Annualized Maintenance Costs Needed to Maintain a Stable Network

Main Roads

Main Roads Managed by Main Road Agency											
Road	Road Class		Length	Vehicle Utilization	Annual Maintenance			Periodic Maintenance			
Type	Number	Description	(km)	(M veh-km/yr)	Fixed (M$/yr)	Variable (M$/yr)	Total (M$/yr)	Fixed (M$/yr)	Variable (M$/yr)	Total (M$/yr)
Paved	1	Traffic: 300vpd - 30% Trucks / Loading: Low	1 400	153	1.40	0.03	1.43	2.97	1.70	4.67
	2	Traffic: 600vpd - 30% Trucks / Loading: Low	550	120	0.55	0.03	0.58	1.88	0.69	2.57
	3	Traffic: 1000vpd - 30% Trucks / Loading: Low	150	55	0.15	0.01	0.16	0.64	0.13	0.77
	4	Traffic 3000vpd - 30% Trucks / Loading: Low	300	329	0.30	0.04	0.34	1.79	0.31	2.10
	5	Traffic: 6000vpd - 30% Trucks / Loading: Low	20	44	0.02	0.00	0.02	0.12	0.02	0.15

Source: Heggie and Archondo-Callao

The resulting annual maintenance cost (annual and periodic) is calculated from the default values provided by the model. The table below shows the format in which default values for maintenance cost and externalities are provided.

FORMAT OF DEFAULT VALUES TABLE FOR MAINTENANCE COST AND EXTERNALITIES

Unit Annualized Maintenance Costs Needed to Maintain a Stable Road Class

Paved Roads

Road Class		Average Daily Traffic	Annual Maintenance (Cost Factor 1.00)		Periodic Maintenance (Cost Factor 1.00)	
Number	Description	(veh/day)	Fixed ($/km/yr)	Variable ($/km/yr)	Fixed ($/km/yr)	Variable ($/km/yr)
1	Traffic: 300vpd - 30% Trucks / Loading: Low	300	1 000	24	2 121	1 212
2	Traffic: 600vpd - 30% Trucks / Loading: Low	600	1 000	48	3 415	1 252
3	Traffic: 1000vpd - 30% Trucks / Loading: Low	1 000	1 000	60	4 286	836
4	Traffic 3000vpd - 30% Trucks / Loading: Low	3 000	1 000	120	5 957	1 043
5	Traffic: 6000vpd - 30% Trucks / Loading: Low	6 000	1 000	180	6 222	1 069
6	Traffic:10000vpd - 30% Trucks / Loading: Low	10 000	1 000	204	6 222	1 386
7	Traffic: 300vpd - 30% Trucks / Loading: Medium	300	1 000	24	2 059	1 275
8	Traffic: 600vpd - 30% Trucks / Loading: Medium	600	1 000	48	3 415	1 469

Externalities

Congested Road	Road User Costs		Road Accident Rates (number per 100 Million veh-km)		
(Y/N)	Without Congestion ($/veh-km)	With Congestion ($/veh-km)	Accidents Rate	Fatalities Rate	Injuries Rate
N			160	4	60
N			160	4	60
N			160	4	60
N			160	4	60
N			160	4	60
Y	0.50	0.70	160	4	60
N			160	4	60
N			160	4	60

Source: Heggie and Archondo-Callao

15.3. EXPECTED RESULTS AND OUTCOME

The model produces a number of output tables. The table below shows, for the hypothetical case, the annual cost of operating and maintaining the different networks on a sustainable basis as well as source of funding. In this table, fixed maintenance costs are costs that are independent of traffic and loading. Variable maintenance costs are costs that are dependent on traffic and loading.

ANNUAL COST OF OPERATING AND MAINTAINING DIFFERENT NETWORKS AND SOURCES OF FUNDING (EXAMPLE)

Annual Costs and Source of Financing

Recurrent Expenditures

			Annual Costs			Source of Financing				
						by User Charges			by Other Revenues	
			Fixed (M$/yr)	Variable (M$/yr)	Total (M$/yr)	Fixed (M$/yr)	Variable (M$/yr)	Total (M$/yr)	% of Fixed (%)	Total (M$/yr)
Recurrent Expenditures	Main Roads	Annual Maintenance	32.30	5.96	38.26	32.30	5.96	38.26	0	0.00
		Periodic Maintenance	128.50	52.34	180.83	128.50	52.34	180.83	0	0.00
		Administration & Other	250.00	0.00	250.00	250.00	0.00	250.00	0	0.00
		Total	410.80	58.30	469.09	410.80	58.30	469.09		0.00
	Secondary Roads	Annual Maintenance	80.50	46.70	127.20	40.25	46.70	86.95	50	40.25
		Periodic Maintenance	157.43	45.06	202.49	78.71	45.06	123.77	50	78.71
		Administration & Other	150.00	0.00	150.00	75.00	0.00	75.00	50	75.00
		Total	387.93	91.76	479.68	193.96	91.76	285.72		193.96
	Tertiary Roads	Annual Maintenance	102.50	67.95	170.45	0.00	67.95	67.95	100	102.50
		Periodic Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	100	0.00
		Administration & Other	100.00	0.00	100.00	0.00	0.00	0.00	100	100.00
		Total	202.50	67.95	270.45	0.00	67.95	67.95		202.50
	Urban Streets and Avenues	Annual Maintenance	78.33	35.01	113.33	0.00	35.01	35.01	100	78.33
		Periodic Maintenance	290.92	61.21	352.13	0.00	61.21	61.21	100	290.92
		Administration & Other	100.00	0.00	100.00	0.00	0.00	0.00	100	100.00
		Total	469.24	96.22	565.46	0.00	96.22	96.22		469.24
	Total		1 470.47	314.22	1 784.69	604.76	314.22	918.98		865.71

Source: Heggie and Archondo-Callao

The source of funding can then be determined from this table. The model assumes that all variable cost are met through user charges. The proportion of fixed cost to be met through user charges is a user input, and the balance of fixed costs is assumed to be met by other revenues (e.g. parking charges). The table below depicts the situation where all fixed costs for secondary roads and streets are sources from other revenues.

PROPOSED FINANCING TABLE			
Road Network	**By User Charges (mil US$ per yr)**	**By Other Revenue (mil US$ per yr)**	**Total (mil US$ per yr)**
Main Roads	33	0	33.40
Secondary Roads	1	1	2.30
Streets	3	8	10.30
Entire Network	37	9	46.00

The model calculates total road user charges collected from a number of tools, namely:

- **Gasoline levy**
- **Diesel levy**
- **Alcohol levy**
- **Annual license fees**
- **Annual load damage fees**
- **Tolls**

This is based on the following parameters for each of the vehicle types (see table below), where vehicle kilometers is used for variable cost and ESA for fixed cost.

ANALYSIS OF VEHICLE USING NETWORK				
Vehicle Type	**Number of Vehicles**	**Kilometers Driven per Year (km/yr)**	**Equivalent Standard Axles per Vehicle (ESA/Veh)**	**Fuel Consumption (1 veh km)**
Taxi Diesel	1,600	12,800	0.000	0.10
Utility	52,273	12,800	0.001	0.13
Light Truck	3,860	14,000	0.030	0.18
Medium Truck	14,166	14,000	1.150	0.29
Heavy Truck	2,576	14,000	1.250	0.43
Articulated Truck	5,151	19,200	2,000	0.53
Bus	6,272	28,000	0.750	0.38
Total	85,901			

The table below shows that a total of US$65.3 million is presently collected from road users (based on current road user charges), which exceeds the estimated need of US$37.1 million per year (as calculated above)

ANALYSIS OF ROAD USER CHARGES COLLECTED			
Current Annual License Fee		**Current Fuel Levy**	
Vehicle Type	**US$ per veh per yr**	**Fuel Type**	**US$/Liter**
Car Gasoline	25	Gasoline	0.20
Car Diesel	25	Diesel	0.10
Taxi Gasoline	18		
Taxi Diesel	18		
Utility	25		
Light Truck	30	Resulting Revenues (mil US$/yr)	
Medium Truck	50	Diesel Levy	30.7
Heavy Truck	60	Gasoline Levy	29.6
Articulated Truck	90	License Fees	5.0
Bus	50	Total	65.3

The model calculates actual charges needed for each vehicle type (see second column of the table below) and compares it to current charges (see third column of the table below). The third column of table below shows that, for all vehicle types, actual charges exceed required charges. This over-recovery is most significant in the case of the vehicle types "cars gasoline" and "taxi gasoline" (12.4 and 12.2 times respectively). These figures result from the fact that road user charges are often regarded as general tax revenue. The model does however determine if different road agencies do in fact get their required share of road user charges collected to enable them to maintain the network.

ANALYSIS OF REQUIRED VERSUS ACTUAL CHARGES			
Vehicle Type	**Charges Required to Cover Variable Costs (c/veh-km)**	**Current User Charges (c/veh-km)**	**Current Charges as a Ratio of Required Charges**
Car Gasoline	0.17	2.11	12.4
Car Diesel	0.17	1.22	7.2
Taxi Gasoline	0.17	2.07	12.2
Taxi Diesel	0.17	1.14	6.7
Utility	0.17	1.50	8.8
Light Truck	0.21	2.01	9.6
Medium Truck	1.61	3.26	2.0
Heavy Truck	1.74	4.73	2.7
Articulated Truck	2.68	5.77	2.2
Bus	1.11	3.98	3.6

The information provided by the RUC model enables road agencies to determine the full cost to be recouped from road users for using the road network. By doing this, the RUC model ensures that the road network is a self-financing system, based on sound economic principles.

15.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

The RUC model ensures that road users pay the full cost of using the road network. This is done by quantifying the full, annualized cost of maintaining and improving the road network, by analyzing income sources and by observing that each vehicle class covers its variable cost from user charges. In doing this, it ensures that the road network is a self-financing system, based on sound economic principles. The RUC model therefore is an invaluable tool, relevant in the case of the management functions “road sector policies formulation” and “network needs assessment”.

15.5. FACTORS AFFECTING APPLICATION

The RUC model is completely customizable to local needs as it uses country-specific input data that should be obtainable from the relevant road management systems. The RUC model, which is provided free of charge by the World Bank, has already been applied in eight developing countries, mostly in Latin America (SSATP, p. 3). The model has however not yet been widely applied in Sub-Saharan African countries. The cost of applying the model in these countries (i.e. populating it with reliable input data) would be minimal if road management systems are up and running for the country under consideration.

Data requirements for the RUC model have been discussed in the sections above. These data inputs should be available when road management systems are up and running in a given country. It nevertheless remains important that default values in the RUC model are calibrated for the country in which it is to be applied.

The tool itself can be found on the SSATP website:

www.worldbank.org/afr/ssatp ⟶ Road Management and Financing ⟶ Tools

SLA Sustainable Livelihood Approach

IN VIEWING RURAL TRANSPORT INFRASTRUCTURE as a critical element of poverty eradication initiatives, it is important that the term "sustainable livelihood" be understood within the context of broader development debates. It is defined as follows: "A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Ashley and Carney, 1999). The SLA is described as "...an improved way of thinking about the objectives, scope and priorities of development, that will better meet the needs of the poor, both at project and policy level" (DfID, 2000a). Key components of SLA are (a) a framework that helps in understanding the complexities of poverty and (b) a set of principles that guides action to eradicate poverty. The framework thus provides information on what needs to be done, whereas the principles provide guidance on how it should be done.

16. SLA: Sustainable Livelihood Approach

16.1. BACKGROUND

When the provision of rural transport infrastructure is viewed as a critical element of initiatives aimed at poverty eradication and the promotion of economic growth and development, it is essential that the concept of "sustainable livelihood" be understood in the context of broader development debates. A sustainable livelihood is defined as follows: "A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Ashley and Carney, 1999). Consequently, there is a need for an approach that emphasizes the concept of "sustainable livelihood" within the context of the provision of rural transport infrastructure.

16.2. DESCRIPTION

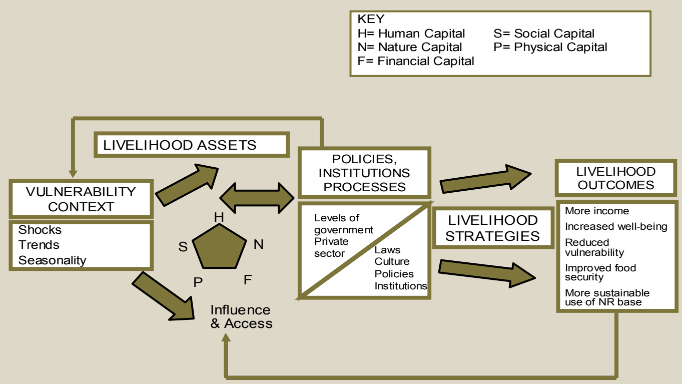
The Sustainable Livelihood Approach (SLA) is described as "…an improved way of thinking about the objectives, scope and priorities of development, that will better meet the needs of the poor, both at project and policy level" (DfID, 2000a). SLA has been used (and is still evolving) since the 1980s. It is being used by a number of development agencies, including the United Nations Development Program (UNDP) and the UK Government's Department for International Development (DfID). SLA, as used by DfID, was formalized in a UK Government's *White Paper on International Development* in 1997. It has subsequently been developed into a *working field tool.* DfID has also developed a set of *Guidance Sheets* to assist field application of the SLA. According to Farrington (2001), it can be discussed at three levels: firstly, a set of principles; secondly, as an analytical framework; and thirdly, as an overall developmental objective. The overall goal of SLA is poverty eradication. This goal is reached through the achievement of six core objectives, shown in the box below.

SLA: CORE OBJECTIVES

- More secure access to, and better management of, natural resources.
- Improved access to high quality education, information, technologies and training and better nutrition and health.
- A more supportive and cohesive social environment.
- Better access to basic and facilitating infrastructure.
- More secure access to financial resources.
- A policy and institutional environment that supports multiple livelihood strategies and promotes equitable access to competitive markets for all.

Key components of SLA are (a) a framework that helps in understanding the complexities of poverty and (b) a set of principles that guide action to eradicate poverty. The framework thus provides guidelines on *what* needs to be done, whereas the principles provide guidance on *how* it should be done. With this framework (shown below) the concept of capital assets is important. The framework also considers how these assets are affected by the "vulnerability context" as well as by "transforming structures and processes" (i.e. policies, institutions and processes), in order to arrive at "livelihood strategies" that lead to various "livelihood outcomes".

FRAMEWORK FOR SLA



Source: DfID, 2000

The guiding principles for SLA are shown in the box below.

SLA: GUIDING PRINCIPLES

- *Be people-centered.* SLA begins by analyzing people's livelihoods and how they change over time. The people themselves actively participate throughout the project cycle.
- *Be holistic*. SLA acknowledges that people adopt many strategies to secure their livelihoods, and that many actors are involved; for example the private sector, ministries, community-based organizations and international organizations.
- *Be dynamic*. SLA seeks to understand the dynamic nature of livelihoods and what influences them.
- *Build on strengths*. SLA builds on people's perceived strengths and opportunities rather than focusing on their problems and needs. It supports existing livelihood strategies.

- *Promote micro-macro links*. SLA examines the influence of policies and institutions on livelihood options and highlights the need for policies to be informed by insights from the local level and by the priorities of the poor.
- *Encourage broad partnerships*. SLA counts on broad partnerships drawing on both the public and private sectors.
- *Aim for sustainability.* Sustainability is important if poverty reduction is to be lasting.

Application of SLA involves five steps, as shown below:

- **Identification of assets, entitlements, activities and knowledge base**
- **Macromicro linked policy analysis**
- **Assessment of key technologies**
- **Identification of microfinance**
- **Recommendations emerging from 1-5**

Important concepts within the SLA context are defined in the box below.

IMPORTANT SLA CONCEPTS

Livelihood: "A livelihood comprises the capabilities, assets and activities required for a means of living" (Chambers and Conway, 1992).

Sustainable livelihood: "A livelihood is sustainable when it can cope with and recover from the stresses and shocks and maintain or enhance its capabilities and assets both now and in the future without undermining the natural resource base" (Chambers and Conway, 1992).

Household livelihood security: "Household livelihood security is defined as adequate and sustainable access to income and resources to meet basic needs" (Frankenberger, 1996).

The concept "sustainability" embraces four elements, namely *environmental, economic, social* and *institutional.* Livelihoods are deemed sustainable when:

- **They are resilient in the face of external shocks and stresses.**
- **They are not dependent upon external support.**
- **They maintain the long-term productivity of natural resources.**
- **They do not undermine the livelihoods of, or compromise the livelihood options open to, other livelihoods**.

It is important to note differences between SLA and other approaches, as listed in the box below.

DIFFERENCES BETWEEN SLA AND OTHER APPROACHES

- It puts people at the centre of development. People - rather than the resources they use or the governments that serve them – are the priority concern.
- It builds upon people's strengths rather than their needs.
- It brings together all relevant aspects of people's lives and livelihoods into development planning, implementation and evaluation.
- It unifies different sectors behind a common framework.
- It takes into account how development decisions affect distinct groups of people, such as women compared to men, differently.
- It emphasizes the importance of understanding the links between policy decisions and household level activities.
- It draws in relevant partners whether State, civil or private, local, national, regional or international.
- It responds quickly to changing circumstances.

Key characteristics shared by SLA and several other approaches are listed below:

- **Community driven development**
- **Rights-based approaches**
- **Asset-based community development**
- **Social safety nets**

Finally, it is important to focus on some myths regarding SLA, as shown in the box below.

MYTHS REGARDING SLA

- We all use the term "SL" to mean the same thing.
- The DfID sustainable livelihoods approach is the only SLA.
- Sustainable Livelihoods is just another framework.
- Sustainable livelihoods projects are just IRDPs repackaged.
- Taking a “holistic” approach means you have to address everything.
- Sustainable livelihood approaches are just about micro issues.
- Sustainable livelihood approaches are just about natural resources and rural issues.

16.3. EXPECTED RESULTS AND OUTCOME

SLA provides a framework that helps in understanding the complexities of poverty. It also provides a set of principles that can guide actions to eradicate poverty. By focusing on the main factors that affect poor people's livelihoods and the typical relationships between these factors, SLA improves the understanding of the dynamics of the livelihoods of poor people. In so doing, SLA can be instrumental in planning new development activities (including transport infrastructure) and in assessing the contribution that existing activities are making towards sustaining livelihoods. As such, it can ensure that rural transport infrastructure constitutes an optimal element of poverty eradication initiatives.

16.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

Network needs assessment, within the context of road infrastructure and poverty alleviation, involves the recognition of rural/social roads as a critical element of poverty alleviation initiatives. In particular, it requires an understanding of the concept “sustainable livelihood” within the broader context of current debates. As SLA provides an improved way of thinking about the objectives, scope and priorities of development that will better serve the needs of the poor at both the project and the policy levels; it enables road agencies to provide rural transport infrastructure in a manner that more optimally addresses the needs of the poor.

16.5. FACTORS AFFECTING APPLICATION

SLA has been applied in a number of countries by agencies such as DfID (one of the first proponents of this approach), Oxfam, UNDP and CARE. There are however a number of factors that may limit the application of SLA. Unresolved issues include the following: how to compare and measure capital assets, differences in the interpretation of the concept *participation*, and the ongoing tension between the value of “increasing participation” and the “desire for scientific rigor”. Other issues listed by the Food and Agriculture Organization of the United Nations (FAO) are program design, entry point, measuring impact, changing structures and processes for sustainable outcomes, working with multiple partners at various levels and balancing natural resource management objectives with poverty-alleviation objectives.

Further information on SLA can be found on the Livelihoods Connect website:

www.livelihoods.org ⟶ Guidance Sheets

SOURCE Standard Overall Ultralite Road Care Estimate

SINCE THE EARLY 1990S, major reforms have taken place in a number of Sub-Saharan African countries, mainly through the Road Management Initiative (RMI), which is a key component of the SSATP. The primary objective of the RMI was to secure sustainable improvements in road sector performance in Sub-Saharan Africa. It soon became clear that it was difficult to prove to key players in both the public and the private sectors that sustainable progress had taken place as reliable road and traffic data, and data for inter-country comparisons, were not readily available. What was needed were simple, objective and less data-intensive methods for performance monitoring. The SOURCE method, developed in response to this need, "... is based on standardized measurements of traffic and common speeds of light vehicles, made for each country over a standardized reference network. The two series of data (traffic/speeds) are aggregated for the entire reference network in the form of a single macro-indicator (a pseudo-speed) that reflects the actual level of service provided by the main roads in each country. Various by-products are also obtained, which include a macro data bank for the network in question".

17. SOURCE: Standard Overall Ultralite Road Care Estimate

17.1. BACKGROUND

Since the early 1990s, major reforms have taken place in a number of Sub-Saharan African countries. These reforms, supported by a number of donor countries, took place mainly through the Road Management Initiative (RMI) which was a key component of the SSATP. The primary objective of the RMI was to secure sustainable improvements in road sector performance in Sub-Saharan Africa. RMI sponsorship came from a number of bilateral donors, as well as the European Union and the World Bank.

It soon became apparent that concrete evidence of positive, sustainable changes was lacking, and that reliable data for this purpose were difficult to access. This applies to both road and traffic data. Even where they do exist, inter-country comparison was not possible in all cases, as is evident from the following extract in the box below.

THE STATUS OF ROAD STATISTICS
(FERNIQUE)

Commonly used road statistics in the form of national aggregates are mostly qualitative (despite appearances which are deceptive) and therefore are not readily usable. It is a fact that far too few countries have permanent road data banks, locally managed and regularly updated, based on objective technical data. Example: out of 45 African countries interviewed in 1998, 41 replied that their data bases did not meet these criteria, 20 road administrations could only provide statistics that were "commonly accepted but with no precise statistical basis". Overall traffic-related data are rarely available except under specific programs. That is why in practice, large-scale systematic monitoring can only exceptionally be based on a pre-existing road data bank.

On a supranational scale (for country-to-country comparisons), the apparent comparability of present statistical series is deceptive due to (1) the lack of unified criteria (from the measurement of deflection to "what the expert says"), and (2) the existence of reference networks that are extremely inconsistent and unstable (in the series examined, we have noted jumps and drops approaching 70% in length over 8 years). The extent of these defects is such that they can cause complete misinterpretation of the basic question progress/no progress?

Given this lack of reliable data, it became clear that there was a need for simple, objective and less data-intensive methods for performance monitoring, in order to produce "proof" to stakeholders in both the public and the private sector that sustainable progress had indeed taken place.

17.2. DESCRIPTION

The purpose of the SOURCE project, launched by RMI in 1998, was to produce an overall indicator of the physical performance of the network, in order to facilitate the monitoring of the actual level of service of the network. SOURCE, marketed as “a large-scale benchmark tool for road networks”, is a low-cost and easy-to-use tool that can be used to answer the following questions:

- **What is the real condition of the road network?**
- **How do new and rehabilitation work programs stand the test of time?**
- **What is the actual level of service provided for users?**
- **How is this level of service changing?**
- **Does the response from the road sector match up to potentialities and requirements?**

The essence of the SOURCE method is explained in the box below.

ESSENCE OF THE SOURCE METHOD
(FERNIQUE)

The SOURCE method is based on standardized measurements of traffic and common speeds of light vehicles, made for each country over a standardized reference network. The two series of data (traffic/speeds) are aggregated for the entire reference network in the form of a single macro-indicator (a pseudo-speed) that reflects the actual level of service provided by the main roads in each country. Various by-products are also obtained, which include a macro data bank for the network in question.

Key concepts of the SOURCE method are explained in the boxes below.

AT THE CENTER OF THE METHOD: THE FLOATING VEHICLE
(FERNIQUE)

Speed and traffic levels are measured simultaneously using the special “floating vehicle” protocol. An ordinary vehicle (the floating vehicle) is integrated into the traffic and alternatively follows a fast vehicle (which has overtaken it) and a slow vehicle (which it has caught up). On the way, the traffic encountered in the opposite direction is counted. This procedure is detailed in the SOURCE handbook.

A STATISTICAL INTEGRATOR
(FERNIQUE)

The accurate measuring protocol assigned to the floating vehicle makes it a 'statistical integrator' able to provide high-quality results. This is the key to the method. It means that once is enough for this "living" statistical integrator (so to speak) to travel the entire network under review, at speeds close to common speeds.

COMMON LV SPEED: A JUDICIOUS APPROACH
(FERNIQUE)

Experimenting has shown that measuring the common speed of light vehicles (LVs) in the dry season offers sufficient correlation with the surface condition of a road (unlike trucks owing to the unknown load factor). The method does not have to take into account other permanent speed-influencing factors (such as the type of road layout). The method applies equally to paved and unpaved roads unlike conventional methods of assessing road condition, all of which are discontinuous by nature. Through suitable processing of the various distortion factors and after adjustment, the sensitivity of the indicator to disparities or changes in the car population is of minor significance (because the speeds are systematically brought back to 90 km/h).

REFERENCE NETWORKS - FOR COUNTRY-TO-COUNTRY COMPARISONS
(FERNIQUE)

A fundamental aspect of the SOURCE method for making comparisons is the establishment of specific reference networks (on which the measurements are made), which statistically reflect basic transport requirements. They provide a standardized method that takes urban demography into account, with additional criteria for trans-border routes, port areas and transit or regional development corridors, but not traffic levels.

The reference networks are classified into 4 ranks of priority (from 1 to 4 depending on the extent of transport requirements). There is a single measurement method, which does not take the rank into account. These networks act rather like "the shopping basket" used to monitor consumer prices. They change little over a time scale of a few years and they are restricted enough to always be within the priority networks determined at national level. It is essential to use these reference networks (only the 3 main ranks) as a basis for making comparisons between countries. However, each SOURCE measurement campaign in a given country ought to be extended to the national priority network. By producing a double series of statistics in this way, it is possible to satisfy two complementary needs (national and trans-national).

The SOURCE model is still being extended to establish relationship between vehicle speed and road roughness. This would provide a relatively cheap method to obtain this parameter, a key input in the planning and programming steps of road management systems.

17.3. EXPECTED RESULTS AND OUTCOME

17.3.1 Macro indicators

Three macro indicators are produced. These indicators are national aggregates that are developed for the entire reference network. They apply to the dry season, and for business times and days. These macro indicators are defined below (RMI, 2000, p. 8):

Primary indicator:

“The primary indicator provided by the model is the "common speed” of light vehicles on the reference network. This indicator is calculated as follows: harmonic mean of LV speeds, measured section by measured section, weighted by hourly LV traffic volumes in both ways of travel. This speed is said to be “common” because it is the most probable speed of a LV travelling on the network, chosen at random. This indicator is expressed in km/h.”

Secondary indicator:

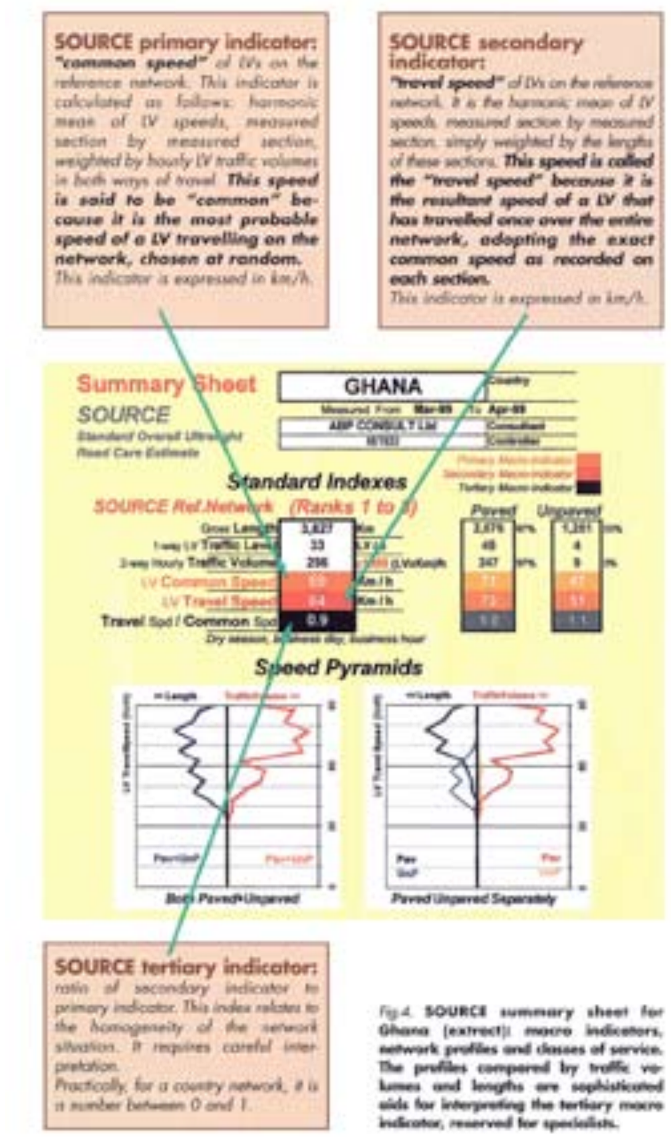
"The secondary indicator is "travel speed” of LVs on the reference network. It is the harmonic mean of LV speeds, measured section by measured section, simply weighted by the lengths of these sections. This speed is called the “travel speed” because it is the resultant speed of a LV that has travelled once over the entire network, adopting the exact common speed as recorded on each section. This indicator is expressed in km/h.”

Tertiary indicator:

“The tertiary indicator is the ratio of secondary indicator to primary indicator. This index relates to the homogeneity of the network situation. It requires careful interpretation. Practically, for a country network, it is a number between 0 and 1.”

These indicators are shown in the centre block of the figure below, where the primary, secondary and tertiary indicators respectively are shown in the fourth, fifth and sixth cell. This figure represents the SOURCE summary sheet for Ghana, containing information on macro indicators for paved and unpaved roads.

SOURCE SUMMARY SHEET FOR GHANA



Source: RMI, 2000

17.3.2 Breaking down of primary indicator

SOURCE is capable of breaking down the improvement of the primary indicator over a three-year period coinciding with a major roadwork program. This is done by calculating the following:

- **Gain in speed due to new works.**
- **Gain in speed due to periodical maintenance.**
- **Loss of speed due to ageing of the network resulting from the climate and traffic, but moderated by routine maintenance.**

17.3.3 Graphic output

Examples of SOURCE graphic output are given in the figure below, which shows the combined LV speed/traffic map produced by the study.

COMBINED LV SPEED/TRAFFIC MAP

Source: RMI, 2000, p. 8

As shown above, SOURCE produces “macro indicators” (all speed-related) reflecting the physical performance of the road network. These indicators serve to enable road agencies to judge the physical performance of the network as well as changes in the level of service resulting from interventions such as the RMI.

17.4. LINKAGE TO ROAD INFRASTRUCTURE MANAGEMENT

As SOURCE produces “macro indicators” (all speed-related) that reflect the physical performance of the road network, it enables road authorities to judge the performance of the network and also to detect changes over time in the level of service resulting from interventions such as the RMI. SOURCE therefore is important with reference to the management function “road network monitoring”.

17.5. FACTORS AFFECTING APPLICATION

SOURCE has been applied in a number of African countries, including Ghana, Cameroon, Guinea and Madagascar. However, SOURCE does not provide information on road condition in sufficient detail to prepare maintenance and improvement programs, and that may limit its use. Instead, it highlights locations in the network where deterioration has taken place by repeated assessments over time. In so doing, it triggers more detailed analyses to determine remedial action. It is thus not intended to replace formal road management systems and databases.

SOURCE has been specifically developed for typical networks in the region. Generally, it is better suited to sections of more than 150 kilometers, and not valid under a certain level of traffic. The “Area of validity” is contained in the box below. This may, in certain cases, imply a limitation on its application.

SOURCE: AREA OF VALIDITY
(RMI, 2000, P. 7)

The SOURCE method is suitable for networks with the following characteristics:

Network Structure

- Few motorways or sections of more than 2 lanes.
- Mixed paved / unpaved roads.
- Mainly deteriorated condition.

Range of Speeds

- Common traffic speeds globally much slower than standard speeds in the West. Mostly below 90 km/h.

Range of Traffic

- Traffic levels usually low to very low compared. Mostly below 700 light vehicles (LV) per way and per day with at least a few major road links exceeding 350 LVs per way and per day.
- Network generally far from saturated (except peri-urban areas).

Contrary to formal road management systems, SOURCE is a relatively inexpensive method of monitoring performance, at an approximate cost of US$ 2 per road kilometer. Another aspect contributing to the low cost of applying SOURCE is the fact that data collection on the entire network is sufficient only once every three years. Surveys on specific road sections can be carried out when necessary. Results can also be obtained relatively quickly, given that between 100 and 150 kilometers of road can be covered per day.

The CD-ROM is available free of charge:

from SSATP

E-mail address: ssatp@worldbank.org

Or from ISTED

E-mail address: Oliver.hartman@icarre.net

18. Summary of Selected Other Tools

18.1. INTRODUCTION

This chapter briefly describes five other tools that have not been covered in Chapters 3 to 17 of this document. These tools are Road Mentor, dTIMS, RTIMS, SuperSurf and the Struman Bridge Management System. Important similarities/differences between these tools are listed below:

- **Road Mentor and dTIMS are "related" as both are road management systems that could be used in conjunction with HDM-4 as each of them complements the HDM-4 model.**
- **RTIM (Road Transport Investment Model) is a software model developed by TRL for the economic appraisal of road investments in developing countries. As such; it is "related" to HDM-4 as both originated from the results of the TRRL studies, and both are aimed at road investment appraisal.**
- **By contrast, SuperSurf and the Struman Bridge Management System (BMS) are more modest in scope and size. In both cases, the CSIR of South Africa was involved in the development of the software. SuperSurf focuses on economic warrants for surfacing gravel roads, and the Struman system facilitates bridge management.**

18.2. ROAD MENTOR

18.2.1 Background

The box below provides important background information to Road Mentor.

BACKGROUND TO ROAD MENTOR
(MOSSO ET AL)

Following the re-organization of the roads sector and the formation of TANROADS and the Road Funds Board in 2000, there has been a greater need for a Road Management System to cover the whole of the national trunk and regional roads network. Performance targets are a feature of the new road maintenance arrangements. Since the beginning of 2001, TANROADS has been working with TRL Limited of the UK on a project managed by TANROADS and jointly funded by DfID and the Roads Fund Board, to provide an improved version of a project level system, Road Mentor 3. The improved system, Road Mentor 4, as well as being more suited to network use, has been rewritten in Visual Basic and uses Microsoft Access tables to store data, both in order to be compatible with current operating systems. It can be run on PCs equipped with either Windows 98 or 2000. The main modules of the new Road Mentor 4 program were completed early in 2002. It was realized that considerable effort would be needed to populate the system with reliable and compatible data. Consequently a 2nd phase of the project is being carried out in which, with TRL assistance, the Road Mentor System would be implemented just within a single Zone. Experience gained in this exercise would be used to plan the subsequent implementation across the rest of Tanzania.

18.2.2 Essence of the approach

Road Mentor is described as "a road management system that has Road Mentor at its core as the road information system from which data can be taken as input to HDM-4 which will be used as the multi-year analysis tool for strategic, program and project analysis" (Katala and Toole, p. 1).

18.2.3 Data types in Road Mentor

Data types in Road Mentor are data on road ordnance, road inventory, pavement condition, traffic and works history. "It also includes a module which will identify homogeneous road sections and create a file of details for use with HDM-4 which will be used as the principal tool for strategic, program and project analysis of maintenance" (Mosso et al, p. 2).

18.2.4 Exporting the HDM-4 network file

The approach for doing this builds on the particular strengths of Road Mentor and HDM-4. As such, they are complementary. The unique role of each is described as follows: "The HDM-4 investment analysis model is used to investigate network level strategies and programs and project level analyses. The HDM-4 model requires information on the network, which will be imported from the Road Mentor asset management system. HDM-4 export file module in the Road Mentor 4 is used to create homogeneous sections automatically by using a series of rules and thereby creating an HDM-4 export file. The export file created is compatible with the HDM-4 input requirements" (Mosso et al, p. 7).

To read more on Road Mentor go to the DfID transport site

www.transport-links.org ⟶ Publications ⟶ Road Management Systems, the Development of the Road Mentor System in Tanzania

18.3. dTIMS

18.3.1 Essence of dTIMS

dTIMS CT (***D****eighton* ***T****otal* ***I****nfrastructure* ***M****anagement* ***S****ystem* – ***C****oncurrent* ***T****ransformation*) is marketed as an asset management software tool. It was developed by Deighton Associates Limited of Canada and released in September 2001. It builds on former dTIMS software developed over a 20 year period. It consists of a set of tools for developing a custom database, as well as custom analysis modules according to the unique needs and requirements of the road authority.

18.3.2 Benefits of dTIMS

dTIMS CT has a number of distinct benefits:

- **A dynamic customized database of infrastructure assets can be set up which:**
  - **Manages multiple location referencing methods for data items of linear networks.**
  - **Transforms multiple sources of related data into new data tables (through a process referred to as Concurrent Transformation, CT) for use in the life cycle cost analysis, in summary reports, etc.**
- **A dynamic customized decision information tool can be set up which can be used for:**
  - **Forecasting and predicting future costs and benefits for each asset element and multiple asset classes, providing both project level and network level detail.**
  - **Multi-year project analysis for establishing priorities for work programs.**
  - **Multi-alternative engineering solutions and treatments for each element, section, bridge, asset class or facility.**
  - **Economic objective optimization of feasible solutions for each element constrained by user defined budgets, resources or restrictions (maximize benefits, minimize agency costs, minimize user costs, minimize total transportation costs, maximize a user defined performance measure, etc).**
- **The impacts of any management decisions can be investigated, namely:**
  - **Delaying projects over several years.**
  - **Establishing a new maintenance strategy.**
  - **Committing must-do projects or existing projects under development.**
  - **Effects of new funding sources or the x% across the board budget cuts, etc.**
  - **Determine the funding requirements to achieve a set of minimum standards.**

18.3.3 Modules in dTIMS CT and cost

The dTIMS CT software has 21 separate but seamlessly integrated modules. The modular nature of the software allows the user the flexibility of an RMS as a basic system, and adding modules at a later stage. A basic system would typically comprise only the Core, Element Locations Mapper, Life Cycle Cost Analyser, Optimiser, Report and Graph Viewer and Expressions Builder modules. This would come at a software purchase price of approximately US$13,320, providing only limited database functionalities. A full comprehensive system, consisting of almost all 21 modules and providing comprehensive database management, analysis and mapping facilities, would cost approximately US$50,248.

18.3.4 dTIMS and HDM-4

As is the case with Road Mentor, dTIMS CT and HDM-4 are complementary systems. This is underlined by the following statement by PIARC et al (2002, p. 10): “The HDM-4 software does not in itself, constitute a complete road asset management system. It does constitute a conceptually complete decision support tool for assessing the worth of road investment. The power of HDM-4 is only fully achieved when it is linked to the road asset database maintained by a roads authority.”

18.3.5 Recent applications in the region

The HDM-III road deterioration models have been locally calibrated for use with dTIMS CT and applied in Botswana, Lesotho, Swaziland, Tanzania, Zambia and a number of provincial road authorities in South Africa, namely Gautrans, North West, Limpopo, Western Cape, Eastern Cape, Northern Cape and KwaZulu Natal.

To read more on dTIMS go to the Road Information Management Steering Group website:

www.rims.org.nz

18.4. RTIM3

18.4.1 Essence of RTIM3

The Road Transport Investment Model (RTIM), issued by the Overseas Centre of the Transport Research Laboratory, is aimed at facilitating the economic appraisal of road investments in developing countries. The model compares road expenditures on road improvements and road maintenance with the operating costs over the life of a road in order to determine if improvements or given maintenance standards are economically justified. RTIM3 (released in 1993) is a new version of the model, and aimed at simplifying it. “The model consists of a series of linked compiled spreadsheets that take the user through the stages of an economic appraisal. It is easy to use and offers context-sensitive help facilities, data checking on input, and tabular and graphical outputs. The model runs quickly and easily on a small personal computer” (Cundill and Withnall, p. 187).

18.4.2 Background to the current version

The current version of the model attempts to address a number of user problems. These problems are listed below, as they are of a general nature, i.e. applicable to most similar tools (Cundill and Withnall, p. 187):

- **Obtaining the necessary input data. The models usually require detailed data inputs describing the roads, the vehicles, traffic flows and compositions, and so forth. In general, the more complex the model, the greater the number of inputs required. Deriving them can be quite beyond the means of many users, who may have to estimate or rely on the default values provided with the models. This may not be appropriate.**
- **Adapting the models to deal with non-standard situations. A large proportion of economic appraisals have aspects that are not-standard-and that are not expressly treated in the models. To deal with them, ad hoc modifications must be made to the input data or to the method of analysis. The full implications of these modifications are easily misunderstood.**

- **Training and retaining model users. Government ministries in developing countries often experience great difficulty training and retaining skilled computer modelers. Frequently, the only significant economic appraisal exercises carried out are conducted by visiting specialists on short-term assignments. When they leave, there is little residual ability to extend or modify their analyses.**
- **Keeping up with research developments. Road investment models incorporate the results of extensive field studies carried out over many years. However, the research findings are not conclusive. New relationships are being developed to improve existing models and extend the models to other applications. An investment model must be able to incorporate new findings without needing a major rewrite.**

18.4.3 Modular structure

Generally, RTIM3 uses the same equations as RTIM2. However, some relationships have been simplified. Facilities have also been added to allow users to adjust relationships. A modular structure has been adopted. "The modular structure makes it possible to use different spreadsheets in different situations. In addition to the alternative spreadsheets for earth, gravel, and paved roads, there is a simple spreadsheet that allows the user to specify the yearly road roughness and maintenance costs rather than having them calculated by the model. If road conditions or traffic levels are not uniform, it may be necessary to divide the road into separate links. The model allows this, and up to five links can be combined in one analysis" (Cundill and Withnall, p. 188).

18.4.4 Cost, applications and way forward

"RTIM3 is issued under license and sold at a nominal price (£150). To date, 100 copies have been distributed to users worldwide. Further spreadsheets on road deterioration are planned to incorporate more recent research findings. The possibility of producing further modules on vehicle operating costs and traffic congestion is under review" (Cundill and Withnall, p. 190).

To read more on RTIM3 go to the DfID transport site

www.transport-links.org ⟶ Publications ⟶ Road Transport Investment Model RTIM3

18.5. SUPERSURF

18.5.1 Background

"SURF+" (as the previous version was known) is derived from "**S**_urfacing of_ **U**_npaved_ **R**_oads_: **F**easibility assessment". SuperSurf uses Excel spreadsheets "as a simple mechanism for carrying out cost comparisons between maintaining an existing unpaved road, and improving it by using various upgrading options. The improvements generally relate to low-cost seals _on in situ_ or local materials, but also include dust-palliative options to allow direct cost comparisons. The package includes mechanisms for incorporating environmental and social costs/benefits, with some guidance regarding the selection of input values for these. The package can be utilized for road in both the rural and urban environment. The design, maintenance and rehabilitation requirements and costs of each alternative for input into the package must be developed by an experienced engineer. However, it is expected that, as far as possible, innovative solutions will be applied" (Sabita, p. 5).

18.5.2 What SuperSurf is not

SuperSurf "does not identify or provide all of the possible upgrading or maintenance options for any particular road. For that you will have to use your own experience and intuition. It is also not a pavement design tool – any road designs will need to be developed outside of Supersurf and the resulting data placed in the correct cells by the user. Similarly, the costs for each of these options (including their maintenance and rehabilitation requirements) will need to be determined independently by the user, especially when innovative solutions are being investigated. Good engineering judgment and experience is essential to optimize the benefits of this package. SuperSurf is also not a "simple pavement management system". It is designed for project level analysis of a single section of road and not for a road network" (Sabita, pp. 8-9).

The manual is available on Sabita website:

www.sabita.co.za ⟶ Publications ⟶ Manual 7

18.6. STRUMAN BRIDGE MANAGEMENT SYSTEM

18.6.1 Background

Bridges and other road structures are key elements in any road network. The effective management and proper maintenance of these structures are therefore essential. For this reasons, the CSIR and Stewart Scott (Pty) Ltd have pioneered the development of this software.

18.6.2 Benefits of STRUMAN

The following are cited as benefits of STRUMAN (CSIR Transportek and Stewart Scott, p. 1):

- **Ensures the primary purpose that defects are identified timeously and repaired economically**
- **Structures are maintained at acceptable levels of service**

- **Remedial work is prioritized and expenditure is optimized**
- **Funds are channeled to more serious defects**
- **Expenditure is reduced on less serious defects**
- **Control of expenditure by management is improved**
- **Knowledge on the current state of structures is obtained**
- **Historical records of expenditure on routine maintenance, repairs and strengthening are kept**
- **Knowledge on deterioration rates of defects is obtained for corrective actions to be taken, thus limiting risks to road users**
- **Budget forecasting**
- **Relevant bridge data may be recorded, assessed and manipulated when required**
- **Offers flexibility in the generation of user defined reports**

18.6.3 Modules in STRUMAN

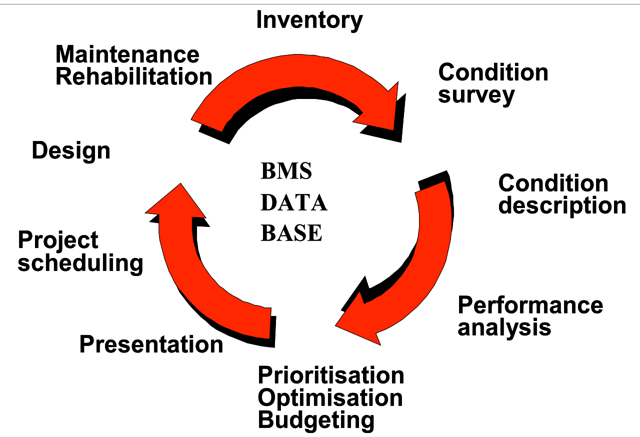
The following modules are included in STRUMAN:

- **Inventory**
- **Inspection**
- **Maintenance**
- **Condition**
- **Budget**
- **Map**
- **Seismic**

18.6.4 Activity flows in a BMS

The activity flows in a BMS are shown in the figure below.

ACTIVITY FLOWS IN A BMS



Source: CSIR Transportek and Stewart Scott, p. 1

With the STRUMAN system, the condition survey is deemed the most important element of a BMS (CSIR Transportek and Stewart Scott, p. 2). “The method chosen to inspect bridges is very important as it provides the only tangible record that can be used for rating of bridges and for the repair budget forecasts. The STRUMAN system differs significantly from other systems in that it is primarily based on the rating of defects. The approach may be summarized as follows:

- **The survey is required to identify and assess defects on bridges.**
- **A standard checklist (inspection sheet) is used to ensure that the inspections are systematic, that all defects are recorded and that no components of the bridges are overlooked.**
- **The defects are rated to rank them in order of priority.**
- **The inspector is also required to list all the remedial work items and to record estimates of quantities.**
- **Defects which do not require immediate repair may need to be monitored and provision is made on the inspection sheet to specify the monitoring frequency".**

Visit the CSIR or the tpa Consulting websites for further information on the Struman Bridge Management System

www.csir.co.za **www.tpa.co.za**

19. Summary of Tools

19.1. INTRODUCTION

This chapter provides a summary of the main features of the tools described in Chapters 3 to 17 of this document. It contains also a comparative analysis of each tool against a set of selected parameters, a classification of the tools in terms of their similarities and finally their web site addresses.

19.2. SUMMARY OF TOOLS

The tools for road management discussed in Chapters 3 to 17 of this document are summarized in the boxes below. From these summaries, some degree of similarities/overlap between certain tools is evident. This results from the fact that they were developed by different organizations, at different times and in response to different needs/contexts. For example, the tools BAA, SLA and IRAP (and to some extent, PRA), all of which focus on basic access, rural roads and poverty alleviation, were developed by different institutions (the World Bank, UK DfID and the ILO respectively) in response to unique country needs and for application in specific contexts. Likewise, both HDM-4 and RED focus on the optimal use of scarce resources. RED, however, was developed later and in response to the need for a tool for unpaved roads that has less stringent data requirements than HDM-4. Similarities between tools are discussed further in Chapter 19.4.

BAA: BASIC ACCESS APPROACH

Description:

Road infrastructure is a prerequisite (but no guarantee) for economic growth and poverty alleviation. To maximize the positive impact of transport infrastructure in general and poverty alleviation initiatives in particular, the “right” balance between (interventions in) the national and the rural road network is equally important – i.e. between national connectedness and basic access. BAA adopts a holistic view in understanding mobility and accessibility needs of rural communities. It provides a means of identifying, ranking and costing projects for addressing these needs, for inclusion in the decision-making process. In doing this, BAA enables road authorities to adopt an inclusive approach in managing road infrastructure, considering both national and rural roads.

Developed by:

The World Bank

BSC: BALANCED SCORECARD

Description:

To ensure the optimal outcome of “road infrastructure management” (namely an effective and efficient road network), road authorities must be functioning optimally from an organization perspective. This will also ensure that available tools, such as those described in this document, are used optimally. The BSC approach is a generic tool for improving the overall performance of organizations. It is a management system that helps align key performance measures with vision and strategy and translate them into action. BSC also provides feedback on internal business processes and external outcomes. It facilitates communication and the understanding of business goals and strategies at all levels in the organization and thus improves feedback and learning.

Developed by:

Drs. Robert Kaplan (Harvard Business School) and David Norton, in the early 1990s

DEFINITE: DECISIONS ON A FINITE SET OF ALTERNATIVES

Description:

Road authorities must ensure that the communities they serve get value for their money and that optimal investment portfolios are chosen. In addition to including all criteria in the decision-making process, this requires project feasibility to be expressed as a single, numerical figure. In a multi-criteria decision-making environment, this often is difficult for a number of reasons: criteria may be conflicting, they may not be expressed in the same units and/or they may be difficult to quantify. Incorporating current thinking and state-of-the-art technology, the DEFINITE software package provides a single measure of project feasibility in a multi-criteria decision-making environment. The process involves identifying and dimensioning decision criteria, and “scoring” investment options in a manner that is scientifically defendable and transparent. DEFINITE enables road authorities to rank investment proposals in terms of their overall feasibility and to select investment portfolios that maximize “value for money”.

Developed by:

Vrije Universiteit of Amsterdam. First version: 1994

HDM: HIGHWAY DEVELOPMENT AND MANAGEMENT MODEL (STRATEGY LEVEL)

Description:

In order to ensure the optimal allocation of scarce resources, interventions in road infrastructure at all levels – strategy, program and project level – must be economically analyzed. Analysis at the strategy level involves, *firstly*, forecasting (a) of long-term funding requirements for target road maintenance standards and (b) of long-term road network performance under varying funding levels, *secondly*, optimal fund allocation (a) to defined budget heads and (b) to sub-networks, and *thirdly*, policy studies, e.g. impacts of changes to the axle load limit, pavement maintenance standards, energy balance analysis, provision of NMT facilities, sustainable road network size, and analysis of pavement design standards. HDM-4 (at the strategy level) assists the road authority in doing all this. The results obtained enable the road authority to make the optimal use of available resources; alternatively, to motivate for additional funds by pointing out the consequences of insufficient funding.

Developed by:

Initiated by the World Bank in 1968

HDM: HIGHWAY DEVELOPMENT AND MANAGEMENT MODEL (PROGRAM LEVEL)

Description:

Interventions in road infrastructure at all levels must be economically justified to ensure the optimal allocation of scarce resources. At the program level, road authorities are required to prepare one-year and/or multi-year work programs under conditions of budget constraints. HDM-4 (program level) assists road authorities in doing this by identifying optimal combinations of maintenance and improvement options, i.e. sections/options that, collectively, maximize return on investment. In this way, HDM-4 ensures that maintenance and improvement programs are optimal and that the best use is made of tax-payer's money.

Developed by:

Initiated by the World Bank

HDM: HIGHWAY DEVELOPMENT AND MANAGEMENT MODEL (PROJECT LEVEL)

Description:

To ensure the responsible allocation of scarce resources, interventions in road infrastructure at all levels – strategy, program and project level – must be economically analyzed. HDM-4 (project level) is a tool for accomplishing this at the project level. Projects could include the maintenance and rehabilitation of existing roads, the widening or geometric improvement of existing roads, pavement upgrading as well as new construction. Analysis at the project level involves determining if discounted benefits of the project over the analysis period at least are equal to its discounted costs. In doing this, HDM-4 assists agencies in making investment decisions at the project level that best contribute to the overall objective of reducing transport cost.

Developed by:

The World Bank

IRAP: INTEGRATED RURAL ACCESSIBILITY PLANNING

Description:

Specific attention must be paid to the accessibility needs of rural households in terms of basic social and economic services, given the notion "roads are not enough". IRAP addresses the accessibility needs of rural households for subsistence, social and economic purposes, to counteract the traditional focus on “higher level” (national) road infrastructure. Key features of IRAP are the integration of elements such as physical infrastructure, means of transport, location planning and quality improvement of services, given the fact that roads alone are no guarantee for socio-economic development, and community involvement. IRAP, which involves a ten-step process, enables road authorities to accommodate the accessibility needs of rural communities in road infrastructure management.

Developed by:

The International Labor Organization

LFA: LOGICAL FRAMEWORK ANALYSIS

Description:

The successful planning, design and implementation of interventions at different levels (project, program and strategy level) require sound processes to be in place. For example, the existing situation must be thoroughly analyzed, a logical hierarchy of the means for achieving objectives must be established, potential risks to achieving objectives and sustainable outcomes must be identified, the means for monitoring and evaluating outputs and outcomes must be established, a summary of the project must be presented to stakeholders in a standard format, and the project must be monitored and reviewed during implementation. LFA provides a generic set of tools for doing this whilst, at the same time, recognizing the importance of stakeholder participation and effective communication. LFA enables agencies to plan, design, implement and evaluate projects in a manner that is internationally accepted and utilized.

Developed by:

First formally applied by USAID

NATA (NEW APPROACH TO TRANSPORT APPRAISAL)

Description:

To be defendable, the appraisal process requires that impacts are summarized in a consistent manner and that the process itself is systemized. In this way, decision makers will be provided with a more transparent basis for project selection. NATA does this by focusing on the extent to which interventions are aligned with national transport objectives – for the UK, these impacts relate to the environment, safety, the economy, accessibility and integration (with other policy objectives). Results are summarized on a one-page Appraisal Summary Table. Other outputs of the NATA process are, firstly, an analysis of the achievement of regional and local objectives, secondly, an analysis of the effectiveness of problem solving (i.e. from a technical perspective), and, finally, supporting analyses, including distribution and equity issues, affordability and financial sustainability, and practicality and public acceptability. In doing this, NATA ensures investment decisions that are best aligned with decision criteria, including policy objectives at the national, regional and local level.

Developed by:

UK Department for Transport

PAM: PERFORMANCE ASSESSMENT MODEL

Description:

Stakeholders require concrete evidence of the importance of their continued support for road maintenance initiatives. PAM was developed for this purpose: it is a simple, network-level macro evaluation tool that demonstrates the importance of the road sector in the economy, assesses the performance of road maintenance systems, and provides indicative figures of the consequences of budget constraints for road infrastructure. It uses country-specific relationships between maintenance spending and road condition, and between road condition and VOC, to determine the optimum level of road maintenance funding for 12 different cases (combinations of road and pavement types). "Optimum level of maintenance funding" is defined as that funding level where total transport cost, consisting of road user cost and road agency cost, is minimized. PAM also quantifies the cost to the economy of under-funding (i.e. of the "funding gap"); alternatively, it determines the benefit to the economy of increased maintenance spending.

Developed by:

The SSATP

PRA: PARTICIPATORY RURAL APPRAISAL

Description:

All stakeholders must be involved in planning processes aimed at improving transport infrastructure and accessibility. This is particularly true in the case of poorer communities, as many planning processes focus on the needs of the richer members of society to the detriment of its poorer members. Generally, this implies a move to decentralized decision-making. PRA, which acknowledges this need, is described as "... a growing family of participatory approaches and methods that emphasize local knowledge and enable local people to make their own appraisal, analysis, and plans. PRA uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders" (World Bank Participation Sourcebook Appendix 1). PRA enables agencies to involve communities in a meaningful way and eliminate the perception that policies and plans are "forced" on them by "higher powers".

Developed by:

The World Bank

RED: ROADS ECONOMIC DECISION MODEL

Description:

To justify proposed investments in transport infrastructure, the benefits and costs of proposed interventions must be quantified and compared. In the case of low volume unpaved roads, benefits often are different to those for primary (national) roads, where benefits typically are in the form of savings in vehicle operating cost and travel time cost. Examples of "other" benefits in the case of low volume roads are those associated with non-motorized traffic, social delivery and the environment. Also, the low-volume unpaved road network is much longer than the primary road network, meaning that the application of sophisticated methods for economic analysis, which normally require a high volume of input data, simply is not feasible as this would be extremely costly. RED has been developed to meet this need. It is a tool for economic analysis for unpaved roads with traffic levels higher than 30 vehicles per day. "RED is a consumer surplus model designed to help evaluate investments in low volume roads. The model is implemented in a series of Excel workbooks that: a) collect all user inputs; b) present the results in a user-friendly manner; c) estimate vehicle operating costs and speeds; d) perform an economic comparison of investments and maintenance alternatives; and e) perform sensitivity, switch-off values and stochastic risk analyses. The model computes benefits accruing to normal, generated, and diverted traffic, as a function of a reduction in vehicle operating and time costs. It also computes safety benefits, and model users can add other benefits (or costs) to the analysis, such as those related to non-motorized traffic, social service delivery and environmental impacts" (SSATP website).

Developed by:

The SSATP

RMS: ROAD MANAGEMENT SYSTEM

Description:

Road management is defined as the "process of maintaining and improving the existing road network to enable its continued use by traffic efficiently and safely, normally in a manner that is effective and environmentally sensitive; a process that is attempting to optimize the overall performance of the road network over time" (Overseas Road Note 15). From this definition, it is clear that there is a need for an all-encompassing tool for doing this. A RMS is intended to meet this need. "A RMS (road management system) is defined here as any system that is used to store and process road and/or bridge inventory, condition, traffic and related data, for highway planning and programming. Associated with the RMS are appropriate business processes to use the RMS to execute the business needs of the highway agency" (McPherson and Bennett, p. 3).

Developed by:
Various road agencies, also commercially available.

RONET: ROAD NETWORK EVALUATION TOOLS

Description:

In addition to providing selected performance monitors of the network (in the Current Condition Assessment module), RONET answers the key question: What is the cost to the economy and selected stakeholders of maintaining the network to the defined (current) standard as opposed to the optimum (desired) standard? And: given the ideal of an optimum standard: What would be the implications for various selected stakeholders? This is addressed in the Performance Assessment module (previously PAM). Ultimately, RONET will also have the functionality of the RUC tool, and, in addition, will be able to perform a number of other evaluations as well, e.g. life-cycle economic evaluation, axle loading impacts evaluation, accidents impacts evaluation, and network improvements evaluation. All this is accomplished by combining country-specific (either default or user-supplied) data with selected (and simplified) relationships from HDM-4, e.g. the road user cost/road roughness relationship, the paved road roughness progression (deterioration) model, and the gravel roads gravel loss model.

Developed by:

The SSATP

RUC: ROAD USER CHARGES MODEL

Description:

Economic theory requires consumers to bear the full cost of the relevant product or service they consume, in order to ensure the optimal and equitable allocation of scarce resources. In the case of road infrastructure, this principle/process is known as road user charging (RUC). The costs to be borne by beneficiaries of road transport – in addition to road user cost itself – are the cost of providing the road network, and external costs such as pollution, congestion and accident cost. RUC implies three steps, namely (a) road pricing, (b) road cost allocation, and (c) road cost recovery. The RUC model "... estimates road user charges required to ensure that, for a particular country, the costs of operating and maintaining all roads are fully-funded, and that each vehicle class covers its variable costs. The model is an Excel workbook that: (i) estimates annualized maintenance costs needed to maintain a stable road network; (ii) defines countrywide annual recurrent expenditures, annual investments needs, and source of financing; (iii) estimates road user revenues from annual license fees, fuel levies, load damage fees, and tolls; (iv) analyzes the allocation of road user revenues and optimizes road user charges; and (v) computes externalities and summary macro indicators" (SSATP website).

Developed by:

The SSATP

SLA: SUSTAINABLE LIVELIHOOD APPROACH

Description:

In viewing rural transport infrastructure as a critical element of poverty eradication initiatives, it is important that the term "sustainable livelihood" be understood within the context of broader development debates. It is defined as follows: "A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Ashley and Carney, 1999). The SLA is described as "...an improved way of thinking about the objectives, scope and priorities of development, that will better meet the needs of the poor, both at project and policy level" (DfID, 2000a). Key components of SLA are (a) a framework that helps in understanding the complexities of poverty and (b) a set of principles that guides action to eradicate poverty. The framework thus provides information on *what* needs to be done, whereas the principles provide guidance on *ho*w it should be done.

Developed by:

UK DfID

SOURCE: STANDARD OVERALL ULTRALITE ROAD CARE ESTIMATE

Description:

Since the early 1990s, major reforms have taken place in a number of Sub-Saharan African countries, mainly through the Road Maintenance Initiative (RMI), which is a key component of the Sub-Saharan Africa Transport Policy Program (SSATP). The primary objective of the RMI was to secure sustainable improvements in road sector performance in Sub-Saharan Africa. It soon became clear that it was difficult to prove to key players in both the public and the private sector that sustainable progress had taken place as reliable road and traffic data, and data for inter-country comparisons, were not readily available. What was needed, were simple, objective and less data-intensive methods for performance monitoring. The SOURCE method, developed in response to this need, "... is based on standardized measurements of traffic and common speeds of light vehicles, made for each country over a standardized reference network. The two series of data (traffic/speeds) are aggregated for the entire reference network in the form of a single macro-indicator (a pseudo-speed) that reflects the actual level of service provided by the main roads in each country. Various by-products are also obtained, which include a macro data bank for the network in question" (SSATP, 2002, p. 2).

Developed by:

The SSATP - RMI (Road Maintenance Initiative) in 1998.

19.3. COMPARISON OF TOOLS IN TERMS OF SELECTED PARAMETERS

In the table below, the tools discussed in Chapters 4 to 17 are classified systematically in terms of selected parameters. This is done to guide the reader in selecting and utilizing appropriate tools. In this table, “optional” means that the answer could be either “yes” or “no”, depending on the context. Explanatory notes are provided at the bottom of the table.

COMPARISON OF TOOLS IN TERMS OF SELECTED PARAMETERS							
Short Name	**Full Name**	**Is road data bank created/ used?**	**Is GIS created/ used?**	**Aimed at entire road network? (see Box 1)**	**Criteria used in prioritization? (see Box 2)**	**Recommended main user (see Box 3)**	**Recommended frequency of use (see Box 4)**
See notes below:		Note 1	Note 2	Note 3	Note 4	Note 5	Note 6
RMS	Road Management System	Yes	Yes	NAT	NA	RA	CON
BAA	Basic Access Approach	No	Yes	RUR	NA	CONS	REQ
BSC	Balanced ScoreCard	No	No	NA	NA	CONS	INT
DEFINITE	DEcisions on a FINITE set of alternatives	No	No	PROJ	MC	CONS, Lend	REQ
HDM (strategy level)	Highway Development and Management model	Yes	No	NAT	RUC (MC)	RA, CONS	INT
HDM (program level)	Highway Development and Management model	Yes	No	NAT	RUC (MC)	RA, CONS	INT
HDM (project level)	Highway Development and Management model	Yes	No	PROJ	RUC (MC)	RA, CONS	REQ
IRAP	Integrated Rural Accessibility Planning	No	Yes	RUR	NA	CONS	REQ

LFA	Logical Framework Analysis	No	No	NA	NA	CONS	REQ
NATA	New Approach to Transport Appraisal	No	No	PROJ	MC	CONS, Lend	REQ
PAM	Performance Assessment Model	Yes	No	NAT	NA	Lend	REQ
PRA	Participatory Rural Appraisal	No	Yes	RUR	NA	CONS	REQ
RED	Roads Economic Decision model	Yes	No	RUR	RUC (MC)	Lend	REQ
RONET	Road Network Evaluation Tools	Yes	No	NAT	RUC	RA	CON
RUC	Road User Charges model	Yes	No	NAT	NA	CON	CON
SLA	Sustainable Livelihood Approach	No	Yes	RUR	NA	CONS	REQ
SOURCE	Standard Overall Ultralite Road Care Estimate	Yes	No	NAT	NA	Lend	REQ

Notes:

Note 0: NA = Not applicable.

Note 1: The question in this case should be interpreted as follows: Is the creation of a databank a key objective/element of this tool? A “no” answer does not mean that a database is not important, but merely that the development of a database is not one of its required outputs.

Note 2: The question in this case refers to the desirability of a GIS for the relevant tool.

Note 3: The question here refers to the main focus of the tool – a focus on a project does not necessarily exclude the network, and vice versa.

Note 4: This question only refers to some tools, therefore the NA response in some cases.

Note 5: A distinction is made between the institution applying the tool (e.g. a consultant using HDM-4) and the end user, i.e. the institution using the results (of the application of the tool). In this case, the focus is on the former – in most cases, the road authority will be the end user.

Note 6: "CON" = on a daily basis; "INT" = at regular, set periods, "REQ" = as the need arises.

BOX 1: FOCUS OF TOOL	
Option	**Index**
National road network	NAT
Rural road network	RUR
Project level	PROJ

BOX 2: CRITERIA USED FOR PRIORITIZATION	
Option	**Index**
Road user cost	RUC
Population served	POP
Social aspects	SOC
Other	Other
Multi-criteria	MC

BOX 3: RECOMMENDED MAIN USER	
Option	**Index**
Road authority	RA
Planning/transport ministry	PTM
Concessionaire	CON
Lending institution	Lend
Consultant	CONS

BOX 4: CRITERIA USED FOR PRIORITIZATION	
Option	**Index**
Continuous	CON
Regular intervals	INT
As/when required	REQ

19.4. FAMILIES OF TOOLS

Tools can be classified in different ways. Every classification system may have merit, depending on the context and purpose. Also, categories may not be watertight in all cases. In the classification below, tools are grouped in terms of their similarities, as indicated by the heading in each case. There are, nonetheless, also intra-group differences (differences within each family group), as explained in the section following the table. The 14 tools have been classified into 8 categories, shown in the table below.

FAMILIES OF TOOLS	
Family	**Tools**
Comprehensive tools for road management	• RMS
Tools focusing on rural road network, accessibility, poverty alleviation, community participation	• BAA • IRAP • PRA • SLA
Tools developed in response to stakeholder requirements for feedback/information	• PAM • RONET • SOURCE
Tools aimed at ensuring economic efficiency in resource allocation	• HDM • RED • RONET
Tools suited for multi-criteria decision-making	• DEFINITE • NATA
Tools aimed at road cost recovery	• RUC • RONET
Generic planning tools	• LFA
Tools aimed at improving organizational efficiency	• BSC

Aspects common to each family are outlined in the headings (in italics) below. Differences within families, where applicable (i.e. cases where there are more than one family member in a category), are summarized below for each family.

Tools focusing on rural road network, accessibility poverty alleviation, community participation
These tools have a common objective, as revealed in the heading, but they differ in terms of the specific focus of each, i.e. in how each tool attempts to reach this objective.

- **BAA, developed by the World Bank, adopts a holistic view and provides a means of understanding, ranking and costing projects for addressing mobility and accessibility needs of rural communities, for inclusion in the decision-making process.**
- **IRAP, developed by the ILO (International Labor Organization), emphasizes the importance of *community involvement* in attempting the *integration of elements* such as physical infrastructure, means of transport, location planning and quality improvement of services.**
- **PRA, developed by the World Bank, emphasizes local knowledge and enables local people to make their own appraisal, analysis, and plans; group animation and exercises are used to facilitate information sharing, analysis, and action among stakeholders.**
- **SLA, developed by UK DfID and based on the concept "sustainable development", provides a framework that helps understand the complexities of poverty (i.e. *what* must be done) as well as a set of principles that guides action to eradicate poverty (i.e. *how* it should be done).**

Tools developed in response to stakeholder requirements for feedback/information

- **PAM, developed by the World Bank, uses country-specific relationships to demonstrate the importance of the road sector in the economy, to determine optimum funding levels for the maintenance of different road and pavement types, and to highlight the cost to the economy of under-funding, in order to convince stakeholders of the importance of their continued support for road maintenance initiatives.**
- **RONET, developed by the SSATP, has the (improved) functionality of PAM plus, eventually, a number of other tools, e.g. RUC and RED.**
- **SOURCE, developed by the RMI (SSATP) and involving on standardized measurements of traffic and common speeds of light vehicles on a standardized reference network, is a simple, objective and less data-intensive method for monitoring the performance of the road sector, to prove to key players that sustainable progress had taken place as a result of the Road Maintenance Initiative (RMI).**

Tools aimed at economic efficiency in resource allocation

- **HDM, initiated by the World Bank back in 1968 with a focus on the analysis of design specifications and maintenance options, is perhaps the most widely known tool for the technical and economic appraisal of road projects, the preparation of road investment programs and the analysis of road network strategies.**
- **RED, developed by the World Bank in the late 1990s, came about in response to the need for a tool for economic analyses in the case of unpaved roads, which is not only less "data-demanding" than HDM-4 but which also considers "other" costs and benefits such as those associated with non-motorized traffic, social delivery and the environment.**

- **RONET, developed by the SSATP, has the (improved) functionality of PAM plus, eventually, a number of other tools, e.g. RUC and RED.**

Tools suited for multi-criteria decision-making

- **DEFINITE, developed by the Vrije Universiteit of Amsterdam (1994) for application in a multi-criteria decision-making environment, expresses project feasibility as a single, numerical figure by identifying and dimensioning decision criteria, and "scoring" investment options in a manner that is scientifically defendable and transparent, allowing investment options to be ranked in terms of their overall feasibility and investment portfolios to be designed in a manner that maximizes "value for money".**
- **NATA, developed by the UK DoT, does not express project feasibility as a single figure (see DEFINITE), but facilitates project selection by systemizing the overall process and summarizing impacts in a consistent manner, providing management with a more transparent basis for decision-making, and ensuring that proposed interventions are best aligned with decision criteria, including policy objectives at the national, regional and local level.**

19.5. TOOLS WEB SITE ADDRESSES

Contact and other details for the different tools are given in the tables below.

TOOLS DISCUSSED IN CHAPTERS 3 TO 18				
Tool		**Version**	**Institution**	**Website**
Short name	**Full name**			
BAA	Basic Access Approach	NA	World Bank	www.worldbank.org/afr/ssatp
BSC	Balanced Score Card	NA	Harvard Business School	www.balancedscorecard.org
DEFINITE	DEcisions on a FINITE set of alternatives	20	Vrije Universiteit of Amsterdam	www.ivm.falw.vu.nl
HDM	Highway Development and Management model	2.0	HDMGlobal	www.hdmglobal.com
IRAP	Integrated Rural Accessibility Planning	NA	ILO (International Labour Organization)	www.ilo.org
LFA	Logical Framework Analysis	NA	AusAID (Australian Agency for International Development)	www.ausaid.gov.au

NATA	New Approach to Transport Appraisal	NA	UK Department for Transport	www.dft.gov.uk
PAM	Performance Assessment Model	1.0	SSATP/World Bank	www.worldbank.org/afr/ssatp
PRA	Participatory Rural Appraisal	NA	World Bank	www.worldbank.org/wbi
RED	Roads Economic Decision model	3.2	SSATP/World Bank	www.worldbank.org/afr/ssatp
RONET	Road Network Evaluation Tools	1.01	SSATP/World Bank	www.worldbank.org/afr/ssatp
RUC	Road User Charges model	3.0	SSATP/World Bank	www.worldbank.org/afr/ssatp
SLA	Sustainable Livelihood Approach	NA	UK DFID (Department for International Development)	www.livelihoods.org
SOURCE	Standard Overall Ultralite Road Care Estimate	NA	SSATP/World Bank	www.worldbank.org/afr/ssatp www.isted.com

TOOLS SUMMARIZED IN CHAPTER 18			
Tool	**Version**	**Institution**	**Website**
Road Mentor	NA	TRANROADS	www.transport-links.org
dTIMS	CT	Deighton Associates Limited (Canada)	www.rims.or.nz
RTIM3	3	TRL (Transport Reserach Laboratory)	www.transport-links.org
SuperSurf	NA	Sabita (Southern Africa Bitumen Association)	www.sabita.co.za
Struman Bridge Management System	NA	CSIR	www.csir.co.za www.tpa.co.za

20. Success Factors for Road Management Systems

This chapter describes the key success factors for efficient use of road management systems based on the World Bank paper by McPherson and Bennet "Success Factors for Road Management Systems".

PROCESSES

- Funding: Have annual budgets in place for data collection and operation of the RMS. Even if this initially requires donor funding support, there should be a phased increase in local budgeting to ensure that the RMS is self-funding within a given timeframe.
- Introduction of an RMS by itself is not a guarantee that it will be used, or that it will be successful. The agency must also follow basic asset management principles. Strong involvement of executives and managers prior to and during the implementation of the system is absolutely necessary.
- Clear and explicit RMS planning and programming cycle/schedule developed with clear deadlines of and correlation between main tasks.
- Annual Reports/Business Plans should be prepared, using 'Asset Value' and other Key Performance Indicators derived from the RMS. This is an executive and managerial responsibility. It also helps put focus on the RMS itself, since it provides the data and improves the chances that budget and funds are available to run the system.
- Institutional support consisting of high ranking decision-makers fully-committed to the asset management/asset preservation 'philosophy'.
- Regular briefings should be given to ministers and other high government officials on the importance of asset preservation, and what is being done to make sure that the preservation of the road infrastructure is dealt with satisfactorily.
- Have specific and realistic key performance indicators, targets to measure asset value and to preserve/enhance that value. Monitor those targets, and assess at the end of each year whether they have achieved them or not, and take appropriate action. By publishing this information in Annual Reports, they are accountable to it.
- Have policies and procedures in place for data collection, and for quality assurance of that data.
- Technical (internal and/or external) auditing must be carried out on data and systems, and the recommendations acted on.
- A program of Continual Quality Improvement is also critical. No system is static. All systems can be improved.

PEOPLE

- There should be an organizational unit established with specific responsibility forthe RMS.
- There should be a budget for the operation of the system, including all staffing, equipment, data collection (contracted or in-house), field travel, quality assurance etc.
- There should be clear job descriptions for the various activities, and a career path for those in the unit.
- There should be a continual training and development program (and budget) for staff to deal with staff turnover and re-training where necessary. This should potentially include Master's or other post-graduate degrees which will increase the attractiveness of working in this area.
- There should be training materials available. For bespoke systems the copyright should reside with the agency.
- Jobs should be filled with appropriately qualified personnel, with good management skills, and with access to and control over their budget.
- Job responsibilities should explicitly include:
    - Management of the Road Network Referencing System – control, verification, education and dissemination to other stakeholders.
    - Data Collection – planning, management, supervision and coordination.
    - Data Quality Assurance – verification and checking of all data.
    - Management Reporting – reporting and presentation to management.
- Strong contract management skills are necessary, especially for agencies that contract out portions of data collection. The agency should follow good basic management principles, covering procedures, records, auditing etc.
- There should be a commitment to Continual Quality Improvement.

INFORMATION TECHNOLOGY

- There should be an IT Division.
- TORs should explicitly reflect the IT support in the agency, they should not implement a system in isolation from the IT strategy of the agency. If necessary, assistance must be provided to define an IT strategy and to implement it.
- Road agencies should consider outsourcing / external hosting of their systems where possible given their local environment and according to their overall organizational policies.
- Any sizeable organization procuring IT should have a Technology Architecture, or explicit technology standards and directions. This is important to avoid a profusion of different infrastructure software (operating systems, databases, GIS etc.) with all the attendant support issues; it is also important in helping to define a replacement / upgrade strategy for hardware and software. There are also distinct economies of scale that can be achieved through centralized procurement of hardware and system software.
- All IT implementations should use commercial off-the-shelf (COTS) products wherever possible.
- For any future implementation of an RMS, a set of functional and technical requirements should be drawn up. Functional requirements should include the functions that the software should perform. From the wealth of experience available, it is relatively easy to determine generic functional requirements of an RMS to suit a road agency of a given size. Key functions that should be in any system are given in Table 5.4 on Page 34. Technical Requirements should describe the technology environment within which the RMS will fit (i.e. hardware, operating systems, databases, GIS, and other applications). This should relate to the agency's Technology Architecture as discussed on Page 30.
- Terms of Reference requiring 'integration' other applications, such as HDM-4, with an RMS should be more precise, to raise client awareness of the issues, and will enable the consultant to get a clearer understanding of the client's needs prior to bidding.
- Agencies should develop and adhere to a long-term IT budget strategy that includes costs of hardware and software maintenance agreements (in addition to hardware replacement strategies). One of the comments from a case study in Asia was "The system has not been upgraded since its initial installation (in 1996) and it shows its age. It was the first MS Windows-based version of this system and is not very user friendly". This is a classic case of what can happen if there is no long-term IT strategy.
- The real requirements for web-enabling of systems should be more carefully assessed, and explicitly stated in Terms of Reference. The client also needs to make sure that their IT infrastructure (including hardware, systems software, databases and GIS) is able to support what they wish to do with a web-enabled system.

DATA COLLECTION

- Data collection equipment and approaches should be tailored to the capacity of the road agency.
- Only the key data that are required for use in decision-making should be collected and stored in the RMS.
- Data should be collected at the minimum level of detail with the most appropriate data collection technology given the constraints and capabilities of the agency.
- Data collection policies and procedures need to be formalized and should be readily available.
- If the agency has concerns about operation and maintenance of specialist data equipment in-house, then consideration should be given to outsourcing of the relevant surveys.
- Outsourcing surveys requires strong management and quality assurance of the contractor. There should also be liquidated damages in the contract in the event the contractor fails to provide quality data in a timely manner.
- Key principles for data collection contracts should be included in Terms of Reference.
- Strict data quality assurance procedures should be adhered to so that all system users have confidence in the data and analyses provided to them.
- GIS data needs to be managed in a more detailed manner than other road data since it is likely to be used by many parties outside the road agency.
- Continual improvement is necessary on all aspects of data collection, quality assurance, and data management.

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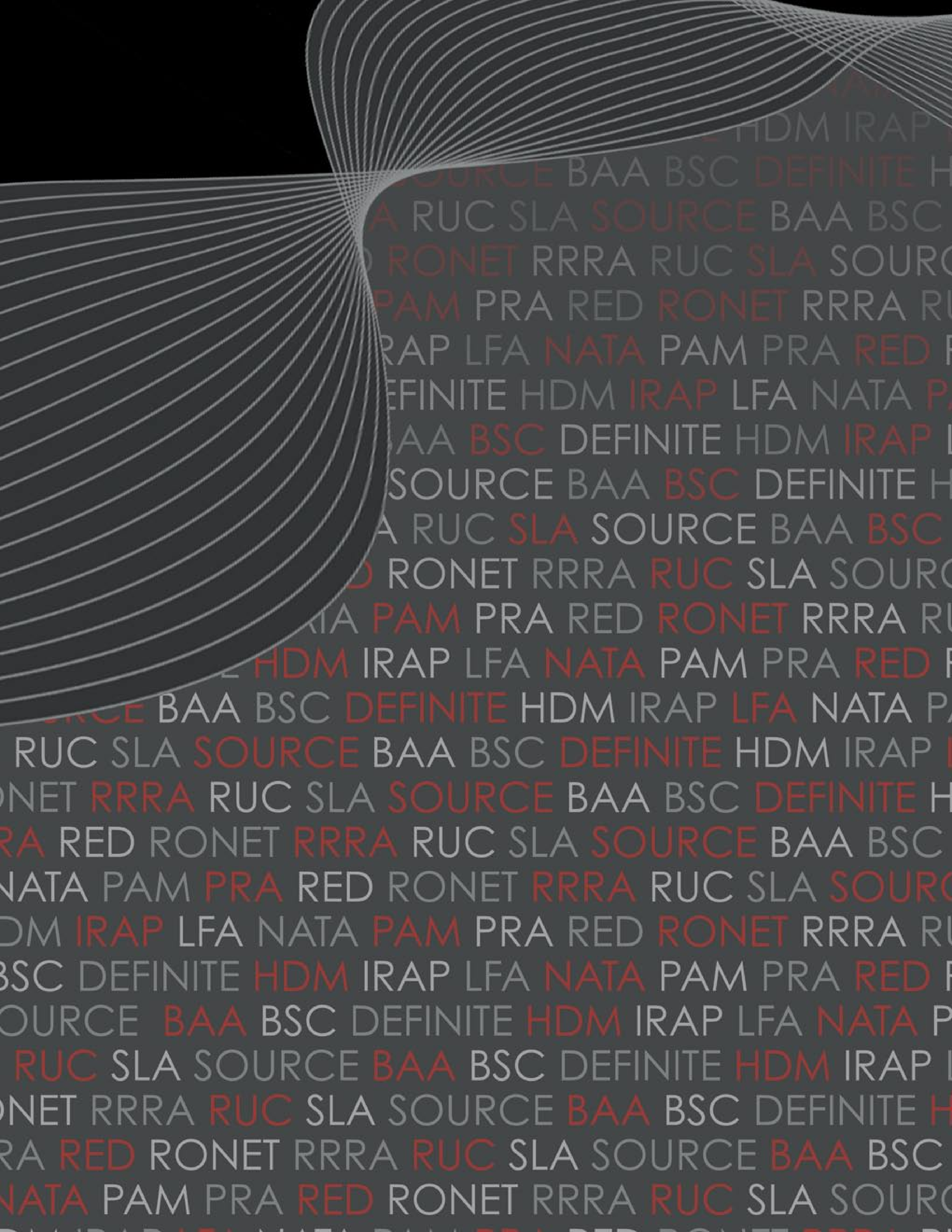
HDM IRAP
BAA BSC DEFINITE
RUC SLA SOURCE BAA BSC
RONET RRRA RUC SLA
PAM PRA RED RONET RRRA
LFA NATA PAM PRA RED
HDM IRAP LFA NATA
BSC DEFINITE HDM IRAP
SOURCE BAA BSC DEFINITE
RUC SLA SOURCE BAA BSC
RONET RRRA RUC SLA
PAM PRA RED RONET RRRA
HDM IRAP LFA NATA PAM PRA RED
BAA BSC DEFINITE HDM IRAP LFA NATA
RUC SLA SOURCE BAA BSC DEFINITE HDM IRAP
RRRA RUC SLA SOURCE BAA BSC DEFINITE
RED RONET RRRA RUC SLA SOURCE BAA BSC
PAM PRA RED RONET RRRA RUC SLA
IRAP LFA NATA PAM PRA RED RONET RRRA
DEFINITE HDM IRAP LFA NATA PAM PRA RED
BAA BSC DEFINITE HDM IRAP LFA NATA
RUC SLA SOURCE BAA BSC DEFINITE HDM IRAP
RRRA RUC SLA SOURCE BAA BSC DEFINITE
RED RONET RRRA RUC SLA SOURCE BAA BSC
PAM PRA RED RONET RRRA RUC SLA