LOW COST ROAD SURFACING (LCS) PROJECT

LCS WORKING PAPER No 5

A TRACTOR AND LABOUR BASED ROUTINE MAINTENANCE SYSTEM FOR UNPAVED RURAL ROADS

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THE LOW COST ROAD SURFACING INITIATIVE

The Low Cost Road Surfacing (LCS) initiative aims to provide documentation and international guidelines on the provision and maintenance of low cost road surfaces and basic access for rural communities in economically emerging and developing countries (EDCs). It is based on a research project funded principally by the British Department For International Development (DFID) under its Knowledge and Research (KaR) programme. The initiative is led by UK-based specialist consultants Intech Associates. Collaboration is being established with a number of organisations with interests or experience in the sector, including CSIR, TRL Ltd, ILO/ASIST Africa and Asia-Pacific, the ILO-SIDA funded Upstream Project and Ministry of Rural Development Cambodia, WSP International, Ministry of Transport Vietnam, Greater Mekong Sub-region Academic Research Network, The Institute of Technology of Cambodia, Chieng Mai University Thailand, the Committee C20 (Appropriate Development) of PIARC (World Road Association) and the International Focus Group. The LCS programme is being implemented over a 3 year period from 2001 to 2003.

The LCS programme is concerned with supporting sustainable improvements in low cost, road surfacing and basic access to support poverty reduction initiatives in rural communities. This implies the effective use of local resources, particularly human resources, locally available and alternative materials, and readily available and low cost intermediate equipment wherever possible. In the situation of scarce financial resources, it also requires the application of affordable and appropriate standards and adoption of techniques suitable for use by the indigenous private sector (particularly small domestic construction enterprises) and local communities. The application of good management practices coupled with adequate technical inputs are also encouraged.

It is intended that dissemination of the guidelines will be through electronic media as well as more traditional publication routes.

INTERNATIONAL FOCUS GROUP

TRL are currently carrying out a number of research projects on low volume sealed and unsealed roads for DFID and a number of other Donors. Intech Associates is carrying out research on low cost surfacing with a number of partners. As part of these projects, an International Focus Group (IFG) has been established. The main function of the IFG is to thoroughly examine technical, economic and social issues arising from the project work. The group will also provide a focus to improve opportunities for dissemination of project results. The IFG being developed will comprise technical experts and engineers from a number of African, Asian Latin American and other countries as well as other international experts. Participation in the IFG will provide opportunities to:

- *build regional and international partnerships*
- *exchange ideas, experiences, information and data*
- *strengthen local knowledge with new information*
- *build on existing local research*
- *promote wider acceptance of the projects themselves*

Four projects listed below, are of particular interest to the IFG. Projects 1, 2 and 4 are part of the DFID's Knowledge and Research programme, whilst Project 3, is a collaborative research project involving a number of different donors:-

Project 1: Reducing Whole Life Costs: Environmentally Optimised Design
Project 2: Minimising the Cost of Sustainable Basic Rural Road Access
Project 3: Engineering Standards for Labour-based Roads
Project 4: Low Cost Road Surfacing

This Working Paper has been revised for the 3rd International Focus Group meeting held in Colombo, Sri Lanka in June 2003. The document is intended to inform and provoke discussion, contributions and dissemination regarding surfacing aspects or rural roads. The LCS Project welcomes dialogue with engineers, managers, organizations, communities and individuals active or interested in the rural transport sector with the objective of the promotion of a sustainable rural access approach for EDCs.

This document is an output from a project funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of the DFID.

A TRACTOR AND LABOUR BASED ROUTINE MAINTENANCE SYSTEM FOR UNPAVED RURAL ROADS

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Abbreviations

DDF	District Development Fund
EDC	economically Emerging and Developing Countries
hp	horse power
hq	head quarters
IFG	International Focus Group
km	kilometre
LCS	Low Cost Surfacing
PIARC	World Road Association
RMU	Road Maintenance Unit

"A TRACTOR AND LABOUR BASED ROUTINE MAINTENANCE SYSTEM FOR RURAL ROADS"

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Synopsis

Effective and sustainable road maintenance systems in Africa are a rare commodity for a range of funding, institutional, economic, technological and management reasons. However the Zimbabwe District Development Fund routine maintenance system for 25,000 km of gravel all-weather feeder roads demonstrates that by identifying and tackling the range of considerable challenges, a low-cost (US$ 260/km/year equivalent)[1] and effective system can be established. The application of tractor and labour technology in a framework of well-justified, regular funding, and efficient and focused management has achieved a methodology which could have lessons for the managers of other national, regional and private road networks.

This paper is based on the 10 November 1999 presentation to the joint meeting of the Appropriate Development Panel of the Institution of Civil Engineers, The Institution of Agricultural Engineers and the Tropical Agriculture Association in London.

Key words: sustainable road maintenance tractor grader

1 1997 prices

1. BACKGROUND

The Zimbabwe road network has developed substantially in the last twenty years. Prior to 1980 (Pre-Independence period), provision of rural roads was not a priority item for the government. There was also limited technical and financial support for construction and maintenance of roads. The 'Rural Areas' of Zimbabwe made up 40% of the total area of the country, most of the rest being allocated to commercial farming. 80% of the population lived in the Rural Areas then known as Communal Lands.

This dense population in the Communal Lands had a road network of barely 3,000 km to service them. These were mainly roads to administrative centres.

This imbalance triggered the need to plan a Rural Road Network that addressed the socio-economic demand for a young nation that had just witnessed a political transformation and was ready to address the social demands of the population. A road network based on socio-economic consideration was then planned using criteria that were sensitive to agricultural potential.

2. DISTRICT DEVELOPMENT FUND

The District Development Fund is a government agency within the Ministry of Rural Resources and Water Development that is charged with the responsibility of providing and maintaining rural infrastructure within the Communal, Resettlement and Small Scale Commercial Farming areas of Zimbabwe.

The District Development Fund (DDF) has, since 1980, been responsible for establishing all-weather road access throughout the rural areas of Zimbabwe. DDF has implemented the planning, selection; construction and/or re-construction and the establishment of proper periodic and routine maintenance for some 25,000 km of rural roads throughout the country. These activities were carried out under a comprehensive Rural Road Programme which was co-financed by the Government of Zimbabwe and the Government of Germany through Kreditanstalt für Wiederaufbau.

One of the notable achievements of this Programme is the successful establishment of the "Routine Road Maintenance System" that was developed during the implementation of the construction programme, and has now established full road maintenance on 25,000 km of road. This system is fully funded by the Government of Zimbabwe and costs the equivalent of only US$ 260 / km / year including overheads, finance and depreciation[1].

The Road Maintenance System is based on the portioning the country into manageable sized Maintenance Unit Areas, each area being typically responsible for between 120 - 160 km of roads. This is the length of road which can be efficiently maintained by a single maintenance unit. The defined maintenance areas mean that maintenance requirements for the area are known, and can therefore be properly planned, budgeted for, and the implementation can be monitored closely according to the work plans, budgets and quality control. Periodic regravelling is managed separately and is carried out by contract or DDF construction units. The main aspects of the routine maintenance system are described in this paper.

3. DDF ROUTINE MAINTENANCE SYSTEM

3.1 The Road Maintenance Unit Area Concept

The rationale behind of Routine Road Maintenance System in Zimbabwe, is based on the

segmentation of districts into a number of unit areas, where individual unit area contains some 120 - 160 km of road under maintenance. These unit areas are each the responsibility of a Maintenance Unit, which is based in a Maintenance Base Camp located centrally within the Unit Area. This base camp accommodates the personnel, equipment and tools required to execute the road maintenance activities.

The main purpose of the Road Maintenance Unit is to ensure that, through proper execution of planned routine maintenance activities, the rural road network is kept in good trafficable condition throughout the year and that the useful life of the road surface is extended until periodic maintenance (regravelling) is required.

The Routine Road Maintenance mainly comprises activities that have to be performed regularly throughout the year. These maintenance work activities are straightforward ***routine*** activities which once mastered are repeated throughout the year according to seasonal requirements. The most effective way to ensure that these activities are properly carried out is to prepare detailed individual work programmes tailored for each Maintenance Unit Area taking account of each road's specific needs. The smaller sizes of the maintenance unit areas make the management of the maintenance easier (less roads to plan, easier organisation for the execution of activities and better control of activities) and reduce the need for highly qualified and more expensive technical staff.

3.2 The Road Maintenance Unit Set-up

The Road Maintenance Unit (RMU) is the core element of the maintenance system (Figure 1).

The RMU comprises a team of trained staff (Maintenance Supervisor, Unit Clerk, Tractor Driver, Towed Grader Operator, and Mechanical Aid), who along with the necessary equipment and material resources operate from a centrally located base camp within the Maintenance Unit Area.

These Area Based Units are completely self-contained regarding their day to day operation and look after all rural roads within their specified influence area. The maintainable length of road is dictated by what can be handled using 1 agricultural tractor, which is the key item of equipment required for towed grading, tyre dragging and transporting the labour and materials. This unit network length is between 120 and 160 km of road, principally depending on traffic quantities and terrain.

The Advantages of the Area Based Maintenance System are:

- The Maintenance Staff live close to their place of work, thereby improving their personal responsibilities to the maintenance work and also providing quick and easy access to the workplace.
- With the fixed roads and resources, the maintenance work cycles can be specified and detailed work programmes prepared for each Maintenance Area.
- The supervision and monitoring of work is easier for smaller quantities and can be achieved by less skilled supervisors.
- Improved usage and efficiency of equipment can be achieved through the proper planning and on-the-spot supervision and support.
- Unproductive travelling to and between worksites is minimized.

Figure 1.

ZIMBABWE RURAL ROAD ROUTINE MAINTENANCE SYSTEM

Routine Maintenance Unit for 100 - 200 network - km

UNIT SUPERVISOR

CAMP SUPPORT

- ACCOMMODATION
- ADMINISTRATION
- STORES
- SERVICING

1 UNIT CLERK
1 MECHANICAL AID

1 TRACTOR
1 TRAILER
1 TOWED GRADER
1 TOWED WATER BOWSER
1 TYRE DRAG PER 20 KM

TOWED GRADING
TYRE DRAGGING
LABOUR TRANSPORT

1 TRACTOR DRIVER
1 ASSISTANT
2 SUPPORT CASUALS



LABOUR ACTIVITIES

- CULVERTS AND CROSSINGS
- DRAIN CLEARING
- GRAVEL PATCHING
- EROSION REPAIRS
- VERGE CLEARING
- SIGNS

UP TO 15 CASUALS









Figure 2.



Figure 3.



3.3 Maintenance Area Base Camp

The **Maintenance Area Base Camps** provide permanent accommodation for the unit staff, as well as office and store facilities (Figure 2). A small basic covered workshop area is also part of the camp structure in order to enable the servicing and repair of the unit's equipment. Additionally **Pull-in-Camps** have been placed at strategic points to provide overnight accommodation where units have to move too far from the base camp.

3.4 Maintenance Unit Core Staff

Each Road Maintenance Unit has four permanent core staff – Unit Supervisor, Unit Clerk,

Tractor Driver and Towed Grader Operator. In addition, a mechanical assistant is responsible for equipment servicing and serves a number of maintenance units.

The Unit Supervisor is responsible for the day-to-day organisation of the Unit, the allocation of equipment, and organisation of duties and activities according to his monthly work programme. The clerk is responsible for unit administration – reporting, fuel, materials and stores control. The tractor driver and towed grader operator are responsible for respective equipment operations.

Casual labour is recruited from the maintenance area to carry out manual operations. The number varies according to the seasonal workload.

4. ROUTINE MAINTENANCE ACTIVITIES

There are two main categories of routine maintenance activities, **Equipment Related Activities** – mainly for maintaining the road carriageway in a smooth and cambered condition, and **Labour Related Activities** for maintaining the drainage systems and road margins.

4.1 Equipment Related Activities

The two types of equipment activities for Routine Road Maintenance are - Towed Grading (Figures 2 & 3) in the wet season and the Tyre Dragging (Figure 4) in the dry season. Both these activities require a tractor to tow the equipment.

The Agricultural Tractor (80HP 2 wheel drive) is a common “tool” in many countries such as Zimbabwe with agriculture based economies, and therefore has a relatively extensive backup service compared to specialised heavy equipment such as motorised graders. In addition tractors are low-cost and simpler to maintain and repair than heavy plant. All of the tractor towed items are locally manufactured in Zimbabwe.

Using the tractor for both the dry and wet season activities means that the tractor is fully utilised throughout the year and it reduces the number of different pieces of equipment required. The tractor is also used with the trailer to transport the labour and materials for the road maintenance.

4.2 Towed Grading

Routine grading (usually 4 passes) is carried out to smooth the carriageway surface and to restore the road profile to its correct shape (using the existing surface material). This grading is most effectively achieved by mechanical means. The two equipment options for grading roads are either a motorised grader or a tractor drawn towed grader. For a number of reasons the (2 tonne) towed grader (cheaper to own and operate, easier to maintain, easier to operate, provides better utilisation of equipment, a better grading tool for rural roads, locally manufactured) is a better choice for routine rural road maintenance.



Figure 4 – Tractor towed grading

Motor graders become ever larger and more powerful to meet the requirements of the high-

wage, low-cost-finance economies of the developed world and are inappropriate tools for routine maintenance of rural roads in a resource-limited environment typical of developing countries. It is interesting to note that when motor graders were first developed some 50 – 60 years ago their rated 75 – 100 hp was quite adequate for road construction and maintenance purposes.

It is also noteworthy that the locally manufactured Arthur Garden 2 tonne towed grader has been in production in Zimbabwe since 1951 with all current model spares being still compatible with the earliest machines. The ex-works price of the towed grader is about US$ 7 - 8,000[2]. In the year 2000 the company produced their 2,000th towed grader.

Grading (without watering and compaction) of the carriageway can only be satisfactorily carried out when the soil condition is damp so that the loosened material can rebind onto the surface. Grading carried out in dry conditions results in severe loss of carriageway material and considerable shortening of the gravel surface's life-span.

4.3 Tyre Dragging

Grading is not carried out during the dry season as it causes damage to the road. There is however a need to keep the running surface smooth during the 7 or 8 months of the Zimbabwe dry season.

Tyre dragging is carried out using a tyre drag which is pulled by the tractor. The tyre drag retards minor deformations (corrugations) on the road carriageway. Tyre Dragging is generally only carried out during the dry season as it is not effective when the road surface is damp or wet.

Tyre drags are deployed at strategic points on the road network and coupled to the tractor to operate on pre-planned circuits of typically 20 – 30 km.

Figure 5 - Frequency and Duration of Equipment Activities

TRAFFIC	TOWED GRADING WET SEASON DEC - MARCH NO. OF CYCLES/MONTH	TYRE DRAGGING DRY SEASON APRIL - NOVEMBER NO CYCLES/MONTH
High	1.0	4
Medium	0.5 (i.e. 1 cycle per 2 months)	2
Low	0.25 (i.e. 1 cycle per 4 months)	1
OUTPUTS	(4 passes)	(4 passes)
Route-km/day	10 route-km per 8 hr day	30 route-km per 8 hr day

2 Price quotation May 2003: AG4000 Standard Towed Grader = US$6,855.00, AG4000 Scarifier Towed Grader = US$7,850.00, AG4000 Universal Towed Grader = US$8,785.00.

Figure 6.

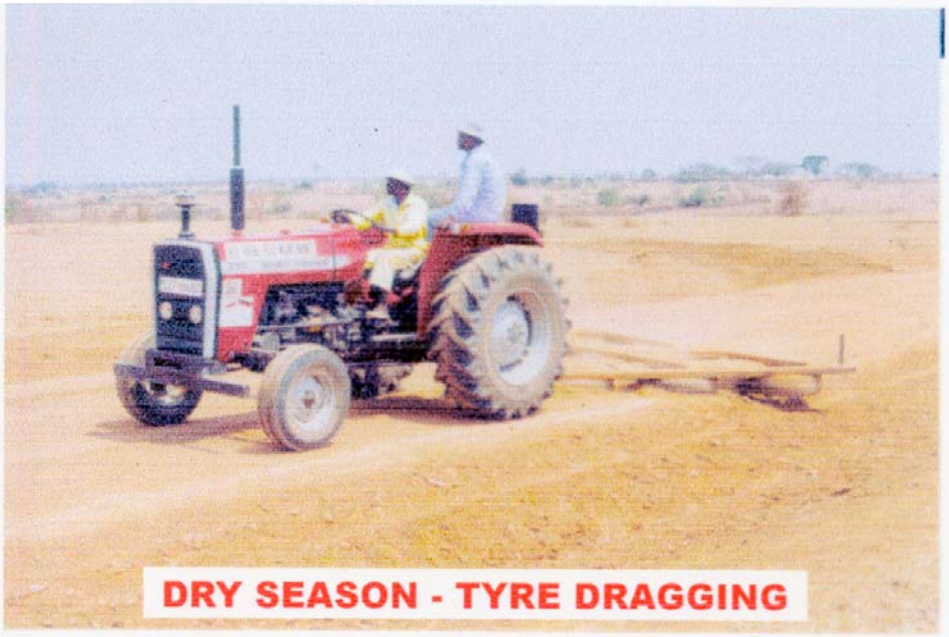


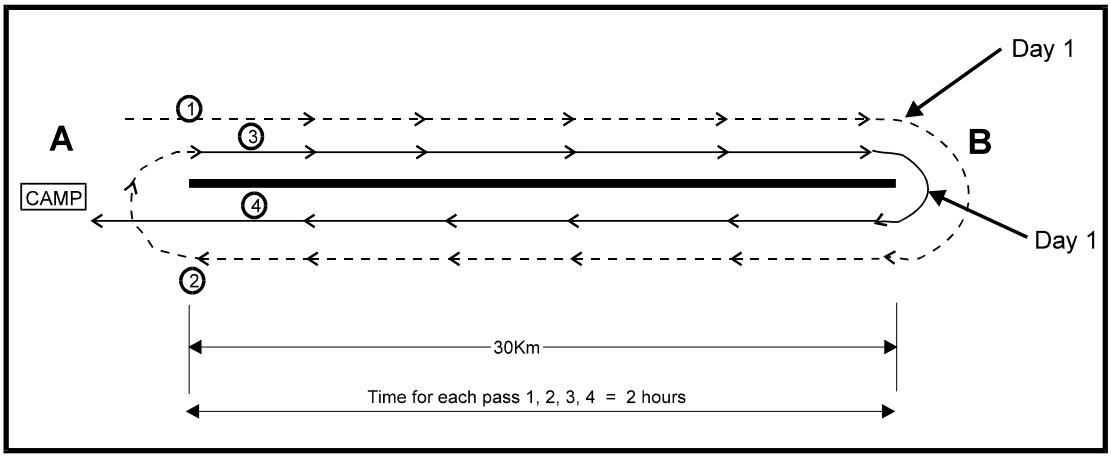
Figure 7.



4.4 Typical Tyre Drag Circuits

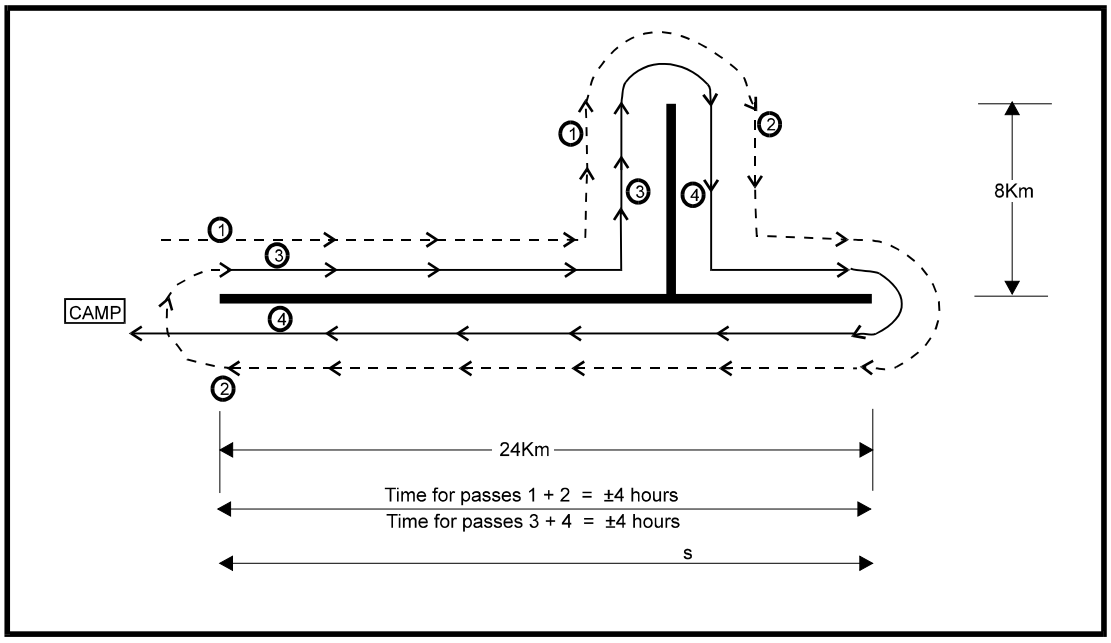
The method for tyre dragging is shown diagrammatically as follows for a single road (the distance shown applies to tyre dragging) for 4 passes of the drag.

Figure 8 – Tyre Drag Circuits



For a situation where two roads are to be tyre dragged to achieve the required minimum daily output of 30 kilometres (e.g. one road is 24 kilometres and second leads off the first and is 8 kilometres long) the sequence is as follows:

Figure 9 – Tyre Drag Circuits for Two Roads



The towed grading follows a similar pattern – however the distances vary to allow for the lower daily distance output.

4.5 Labour Related Activities

Labour activities include - repair of potholes, verge clearing, opening of drainage structures and sign maintenance. It has been found for a number of reasons (length of dry season, organisational, supervision and labour management difficulties) that the length-men system

is not satisfactory for the DDF network circumstances. Employing casual labour according to the specific maintenance requirements is much more effective. These casual employees are local residents who live within the maintenance unit area and are recruited according to the maintenance requirements. The types of labour activities that are required, are dictated by the season.

Patch Gravelling
Patch gravelling is carried out to repair minor defects on the road surface by adding new surface material to rough or eroded areas of the carriageway. This consists of importing suitable material to the road and placing the material on the road.

Clearing Drains
Clearing drains is carried out to remove materials (rock, silt, sand, weeds, bushes, tree trunks or other debris) that may collect in the drains thus allowing the water to flow freely. This includes side drains, mitre (turnout) drains, catchwater drains etc.

Verge Clearing
Verge clearing comprises the cutting of grass on the sides of the road and cutting or removing of any bush, trees, etc. which may affect the vision of road users.

Road Furniture Maintenance
Road furniture are the markers, guide stones, signs etc. which need to be repaired, repainted or replaced as necessary in order to maintain them in good condition.

5. WORK ORGANISATION WITHIN THE MAINTENANCE UNIT

The work organisation is based on the need to complete a specified number of work cycles over the year. The type of activity in a work cycle is determined by the time of the year (wet/dry season activities) and the number of cycles is determined by the traffic quantity on the road and the terrain.

The key item affecting work organisation and implementation is the tractor. It has to handle both the equipment activities (towed grading or tyre dragging) and transport of labour and maintenance materials.

While labour can walk to work when close to a base camp or pull-in camp, at other times the labour component has to be transported. Once transported to the work site however, the tractor is no longer required for transport until the end of the day and can be used for tyre dragging or towed grading activities.

5.1 Work Plans

In order to ensure the proper utilisation of the labour and equipment, the roads in each of the maintenance unit areas are divided into sections. Detailed monthly work programmes are then prepared for each maintenance area, taking account of the seasonal activities, and the movement of equipment to service both the equipment and labour related activities.

Contingency time is built into the programme to compensate for any road sections that require additional work or for equipment down time. With the area based system, the maintenance staff are on site, and soon learn where specific maintenance problem areas are on the roads, and what is required to contain these problems. This is then built into the work plan.

5.2 Planning, Monitoring and Control

The maintenance is closely monitored by provincial staff who are involved in all aspects of the maintenance (Figure 10).
Regular **Co-ordination Seminars** are held which include Head Office, Provincial and the Maintenance Unit Staff. During the seminars each unit presents its work achievements and plans. Any problem areas are discussed and action plans and programme adjustments made accordingly.

The Provincial Staff then follow-up the seminars with site visits, monitoring the work against the presentations and plans – and assisting and instructing the maintenance units where required.

All planning and reporting at Field, District and Provincial levels is achieved without computers. Computers are used only for head office data management.

6. COSTS

The cost analysis in Figure 11 demonstrates the low cost and efficiency of the system.

7. SUMMARY

The routine maintenance system described in this paper has been developed since 1985 by the District Development Fund and has been successfully implemented across the country.

Presently the maintenance system is established on 25,000 km of road through 192 maintenance areas. Each of these areas has an established Maintenance Unit Base Camp, a fully equipped Road Maintenance Unit, and a full complement of trained Maintenance Unit Core staff.

The proof of the maintenance success lies in the good condition of the rural road network. The roads have generally been kept in good condition throughout the recent years despite exceptional rainy seasons and severe droughts.

DDF continues to invest considerable effort and resources in the Recruitment and Training of the Maintenance Unit Core Staff to ensure a continued high standard of Routine Road Maintenance.

The summary assessment in Figure 12 summarises the reasons for the system's success.

Figure 10 - Routine Maintenance National Organisation

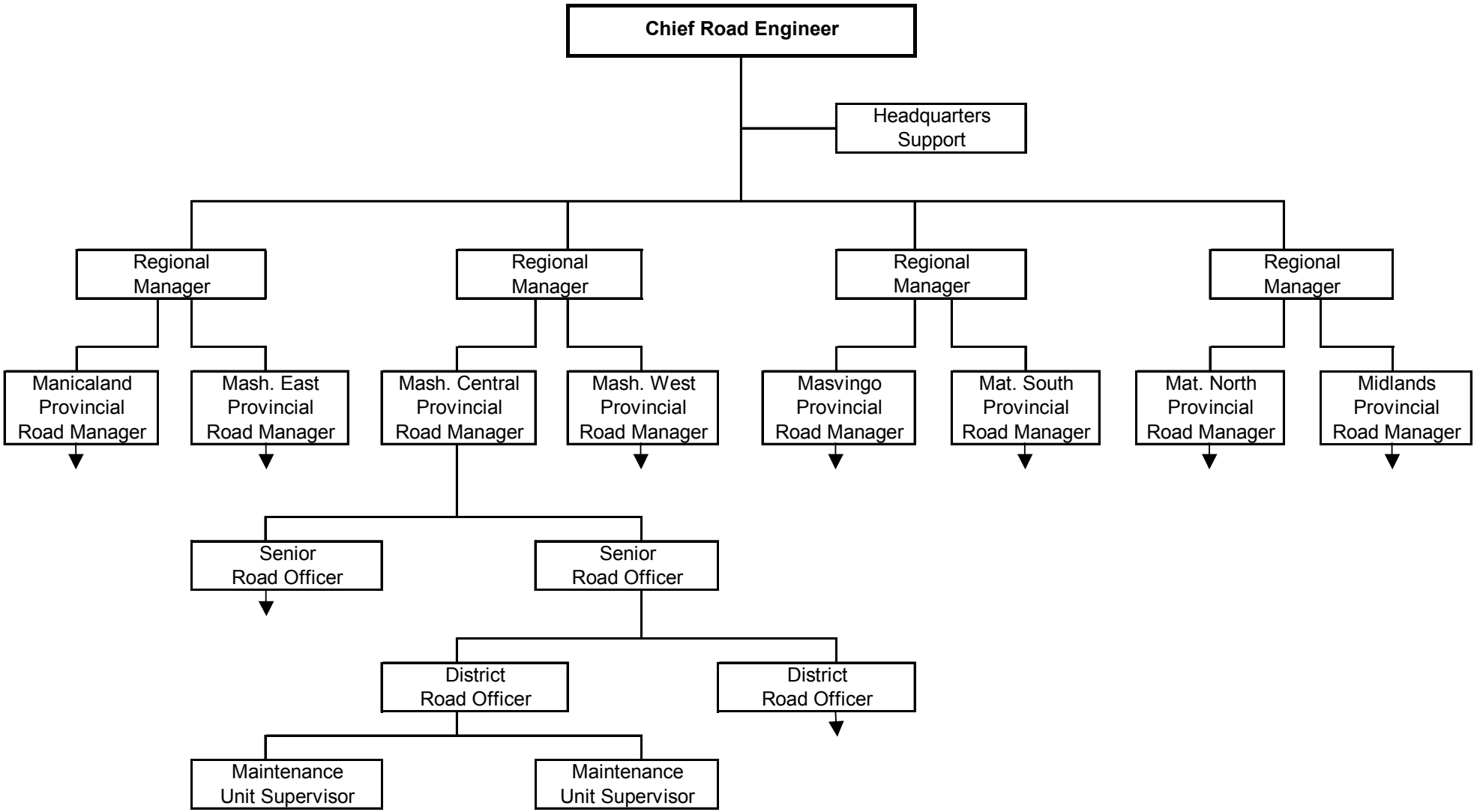


Figure 11 – Assessment of Real Direct and Overhead Costs

DDF Routine Maintenance System for District Roads

Costs have been calculated for two extreme cases of the road network under the responsibility of a standard maintenance camp i.e. 100 km and 200 km (network average = 150 km). Excludes Erosion Control and Bridge repair works.

Prices are mid 1997. US$1=Z$ 12

						ANNUAL COSTS (Z$)	
					Network km	100	200
1.	**DIRECT COSTS - ANNUAL**						
1.1	**Labour**						
	Monthly wage rate	608	Z$/month				
	Average monthly casual labour force - 100 km			7			
	Average monthly casual labour force - 200 km			14			
	Annual casual labour costs					51,072	102,144
1.2	**Handtools @ 5% of labour costs**					2,554	5,107
1.3	**Equipment**						
	Finance/opportunity cost on capital		15	%			
	FINANCE/OPPORTUNITY	cost new	life years	residual%			
	MF 275 Tractor (70 hp)	240,000	10	15		19,800	19,800
	AG 4000 Towed Grader	85,000	10	20		7,013	7,013
	5 tonne Trailer	60,000	10	10		4,950	4,950
	4,500 litre Bowser	60,000	10	10		4,950	4,950
	Tyre drag/20 km	500	10	0		206	413
	DEPRECIATION						
	MF 275 Tractor (70 hp)		using			20,400	20,400
	AG 4000 Towed Grader		the			6,800	6,800
	5 tonne Trailer		above			5,400	5,400
	4,500 litre Bowser		assumptions			5,400	5,400
	Tyre drag/20 km					250	500
	Towed gradings/year (average)		4				
	Tyre draggings/year (average)		12				
	Tractor hours/road km/year		4.4				
	SPARES & SERVICE PARTS	@	3	% of cost		5,874	11,748
	including tyres and consumables			new per 1,000 hours			
	FUEL	@	6	litres/hour		10,560	21,120
		@	4	Z$/litre			
	LUBRICANTS	@	5	% of fuel costs		528	1,056
	INSURANCES	@	2	% of equipt cap.		8,900	8,900
1.4	**Materials**	@	200	per km/year		20,000	40,000
1.5	Contingencies	@	5	%		8,733	13,285
				TOTAL - DIRECT COSTS Z$		**183,389**	**278,985**
				COST Z$ PER KM		**1,834**	**1,395** *1.*
2.	**UNIT OVERHEADS**						
	Facilities and Buildings	Capital Cost (Z$)		250,000	Including Pull-in camps		
	Finance					19,375	19,375
	Depreciation	over	30	years		8,333	8,333
	Maintenance & Repair	@	0.4	% asset v.		1,000	1,000
	Finance for store stockholding		20,000	Z$ value		3,000	3,000
	Unit Supervisor		32,400	inc. allow.		32,400	32,400
	Clerk		25,200	Inc. allow.		25,200	25,200
	Tractor Driver		22,800	Inc. allow.		22,800	22,800
	Towed Grader Operator		12,000	Inc. allow.		12,000	12,000
	Mechanical Assistant		25,000	Inc. allow.		25,000	25,000
	Administration/telphone etc.					1,500	1,500
				UNIT OVERHEADS		**150,608**	**150,608**
				COST Z$ PER KM		**1,506**	**753** *2.*

3. HQ & PROVINCIAL OVERHEADS

(8 Provincial offices)	divided by	190 Units			
Salaries (HQ & Provinces)			3,500,000		
Personnel Allowances & expenses			1,000,000		
Supervision Vehicles			3,000,000		
Equivalent office rental cost			300,000		
Administration/Stationery costs			100,000		
Telephone and Communications			60,000		
Insurances			50,000		
Training & Evaluation Costs			750,000		
			8,760,000	46,105	46,105
		HQ & PROVINCIAL OVERHEADS		**46,105**	**46,105**
		COST Z$ PER KM		**461**	**231** *3.*
4. TOTAL REAL COST Z$ / KM, DIRECT COSTS & OVERHEADS		***(1 + 2 + 3)***		**3,801**	**2,378** ***4.***
		US$/km Equivalent		***317***	***198***
				for 100 km	*for 200 km*

Figure 12 - DDF Routine Road Maintenance System - Reasons for Success

- *Uses Appropriate, Low-Cost & Largely Locally-Based Technologies*
- *Priority given to Routine Maintenance rather than Periodic Maintenance and Construction*
- *Routine Maintenance is carried out as a 'Routine' Activity*
- *Routine Maintenance is separated out from the operations which require particular Technical & Management Expertise (Construction and Periodic Maintenance)*
- *Government has been convinced of the importance of Routine Maintenance and is willing to Fund it Sufficiently*
- *Efficient Organisation & Management Systems - Low Overheads*
- *System is freed from Bureaucratic Constraints of the Civil Service*
- *Managers able to actively Manage the Human Resources*
- *Managers able to Motivate to achieve Performance*
- *Active Planning of Work involving Field Managers*
- *Ongoing Programme of Training & Re-training*
- *National Coordination, Consistency and Standards*
- *Effective Performance Monitoring Systems*
- *Roads are initially brought to a "Maintainable" Condition*
- *System is adapted to Seasonal Maintenance Requirements*
- *Sufficient Flexibility built into System to tackle Contingencies*
- *Simple Equipment which is Standardised, Specified to Match requirements, Easy to Support & Well Managed*
- *Long Equipment Operating Lives achieved (about 10,000 hours per tractor*
- *Effective Equipment Replacement Policy*

References

1. DDF programme documentation
2. Equipment and Rural Road Maintenance Cost Study for Department of Roads, MOTE, Zimbabwe and Association of Rural District Councils, Intech Associates & Sesani Projects, November 1998.
3. MART Handbook of Intermediate Equipment for Roadworks in Developing Countries, Robert Petts, 1999.
4. Road Maintenance Management, Concepts and Systems, Robinson Danielson and Snaith, 1998.
5. Commercial Management and Financing of Roads Ian Heggie & Piers Vickers, World Bank Technical Paper no 409, 1998.
6. Physical Planning Programming and Monitoring, Robert Petts, Paper for the Sub Sahara Africa Transport Program, Road Maintenance Initiative Seminars, World Bank 1989.
7. Towed Graders and Tractor based Maintenance of Low Volume Roads, Dr T.E. Jones and R C Petts, Fifth International Conference on Low Volume Roads, USA, 1991.
8. Maintenance of Minor Roads in Kenya, Dr T.E. Jones and R C Petts, Fifth International Conference on Low Volume Roads, USA, 1991.
9. Technical Manual, Minor Roads Programme, Intech Associates for Ministry of Public Works, Kenya, January 1992.
10. ***Roads 2000***, a programme for labour and tractor based maintenance of the classified road network, paper for the World Bank Road Maintenance Initiative (RMI) road maintenance policy seminar, Robert Petts, Nairobi 2 - 5 June 1992.
11. Agricultural Tractors in Roadworks, Robert Petts, and other MART Working Papers, 1995-1997.

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