ECONOMIC COST/BENEFIT AND VALUE FOR MONEY ANALYSIS OF AFCAP RESEARCH OUTPUTS

Inception Report by Robin Carruthers

December 2012

This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

This material has been funded by UKaid from the Department for International Development, however the views expressed do not necessarily reflect the department's or the managing agent's official policies.

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1. Introduction

This Report describes how we propose to update the approach and method of analysis indicated in the Technical Proposal, based on what has been learned through a trial application of the original approach. The trial application was extensive, but in many instances had to make do with synthesized data as the actual data was not yet available. However, the search for the data led us to realize that some of what was thought to be available was not, particularly that needed for the proposed Connectivity approach to selection of links to be upgraded.

We also realized that the number of runs of the ROCKS, RUCKS RED and RONET models that would be needed was many more than anticipated, so we had to develop an abbreviated approach that would require fewer runs of the model without compromising the reliability of the results. It was also apparent that the structure of the models was not appropriate for dealing with many of the variables to be included in the analysis, and that some changes would need to be made to them for them give us the results needed.

Countries included in the analyses

We seek confirmation of the countries that we are expected to analyze to assess the potential impact of a LVSR approach to the upgrading of earth and gravel roads compared to a continuation of conventional surfacing methods.

The terms of reference refer (on page 21 of the Request for Proposals) to "countries where AFCAP operates excluding Ghana, Zambia, South Sudan, DRC and South Africa." On page 20 of the same document the countries in which AFCAP operates are listed as the above plus Ethiopia, Kenya, Malawi, Mozambique and Tanzania. But the website of AFACP also mentions Zimbabwe and makes mention of activities of AFCAP relative to roads in Botswana.

We would appreciate confirmation that the five countries for which the analysis is expected to be carried out are: Ethiopia, Kenya, Malawi, Mozambique and Tanzania, and that neither Botswana nor Zimbabwe or any other country is expected to be included in the Analysis.

2. Approach

The basis of the Approach will remain the same as in the Technical Proposal, but based on the experience of the trial application, many of the details have changed. Although a two stage approach will still be used, these stages are now perceived rather differently. The first stage analyses will be at the level of a road link and the second stage analyses will be at the level of road networks.

Analytical tools

The World Bank has developed a suite of four programs for use in the evaluation of rural roads. We will make extensive use of three of these models and the databases that support them in our Stage 1 analyses and the last of them in the Stage 2 analyses

The Cost Knowledge System (ROCKS) is database of road construction and maintenance costs for different categories and roads and different surfaces. We will use this model as the basis of our estimates of the life cycle costs for earth, gravel, SST and LRSV roads.

The Road User Costs Knowledge System (RUCKS) provides a database and framework for estimating vehicle operating costs and occupants time costs for use in the economic evaluation of road projects, including the upgrading of earth and gravel roads to paved surfaces, including LVSRs since from the users perspective these are the same as other types of paved roads with the same surface roughness.

The Roads Economic Decision model (RED) was specifically designed for the making of economic decisions relating to low volume roads. We will use it for the evaluations made at the link level in Stage

1 of the upgrading of a standard 10km section of road (separately for gravel and earth roads in poor and very poor conditions) to gravel (only for earth roads), SST and LVSR surfaces for two standard situations - a flat terrain and a dry climate, and a mountainous terrain and a wet climate. The parameters within the RED model will be used for estimating the road and column multipliers to be applied to these standard situation to evaluate upgrading under the other terrain and climate conditions.
The results obtained from the application of ROCKS, RUCKS and RED will provide many of the inputs (other than the network data itself) to ***the Road Network Evaluation Tool (RONET)*** model that will be used in all the network evaluations in Stage 2 of the Study.

First stage

The first stage will involve analyses of hypothetical 10 km road links using the RED model, each link having a predetermined combination of characteristics of surface type (4 types), terrain type (3 types), climate type (3 types) and traffic level (2 levels[1]). This will give a total of 72 standard road links. The data and analysis will be organized on the basis of 3 x 3 matrices of terrain type by climate type. There will be six sets of such matrices, one for each surface type and traffic level. Most of the inputs to the RED model will come from the ROCKS and RUCKS models.
There will be three sets of analysis that will make use of this data structure:

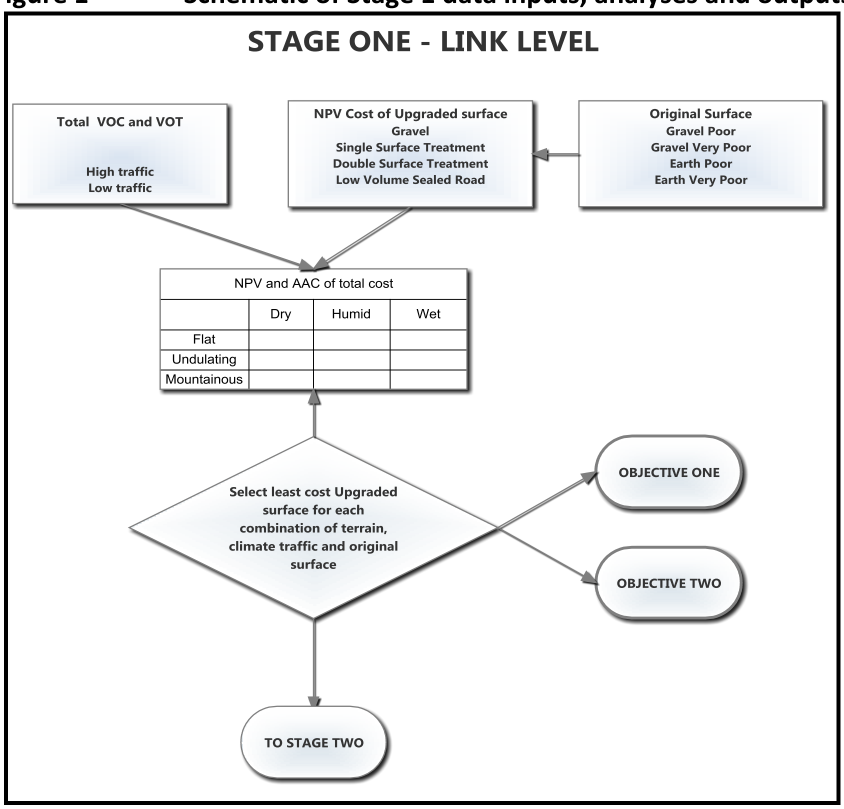
- estimation of life cycle investment and operating costs, expressed as net present values (NPVs) and average annualized costs (AACs), both based on a twenty year analysis period. The estimate of life cycle costs for three of the four road types (earth, gravel, single surface treatment (SST)) are already available from previous work, but those for LVSR will need to be estimated as part of the Study. From the investigations made during the trial application of the Approach, very little data on which to base these estimations exists. At this stage of the analysis only one type of LVSR will be considered, and the choice will be based on a life cycle costs comparison for flat terrain, humid climate and 50 vehicles per day of three representative types of LVSR – Single Otta seal plus sand seal, Heavy Cape Seal and a Double Otta Seal. We will benefit from help from date on AFCAP project reviews of the data for these types of LVSR on which the life cycle costs can be estimated:
- estimation of vehicle operating and user time costs, also expressed as NPVs and AACs, and;
- estimation of the NPV and AAC of total cost investment and maintenance and user costs, using the outputs of the two previous analyses.

By comparing the total NPV and average annual cost for each of the four different surface types under each combination of terrain type, climate and traffic level, we will determine the road type with lowest cost for each of the 18 combinations of parameters.
This analysis will allow us to determine under which combinations of the three variables (terrain, climate and traffic) a LVSR solution has a lower total economic cost than the other surface types - gravel, and SST. (Objective 1)
To satisfy Objective 2 a rather more developed method is needed. We will add the initial surface type and condition of the road link being upgraded to the sets of matrices that needs to be analyzed. We will consider just two surface types for upgrading (earth and gravel) and a single surface condition (very poor), thus increasing the number of combinations of parameters from 72 to 144 – a significant but necessary increase in the analytical effort to meet Objective 2 (the economic costs of upgrading gravel and earth roads to paved standards using a LVSR approach).

[1] The two traffic levels will be average AADT of 50 and 200

In an attempt to reduce the effort, we propose to undertake most of the analysis for just two cells of each 3 x 3 matrix (one combining flat terrain and dry climate and the other mountainous terrain and wet climate) and estimate the values for each of the other cells by using a combination of column and row multipliers. This will reduce the number of runs of the RED model at the link level to a more manageable twelve (2 surface types to be upgraded (earth and gravel), 1 original condition (very poor), 2 traffic levels (50 AADT, 200 AADT), and 3 upgraded surface types (gravel, SST, and LVSR).
The success of this simplification will depend on the reliability of the data for the two base cells and of the multipliers for the other columns and rows.
Whether we use currently available or new data, the number of runs of the RED model will be the same (12). The output of this first stage analyses will be an indication for which combination of parameters (terrain, climate, traffic level and starting road surface and condition) an LVSR solution is better than either of the considered alternatives.

Figure 1 Schematic of Stage 1 data inputs, analyses and outputs



Second stage

The second network stage of the analysis will apply the results of the Stage 1 analyses to the unpaved road network of each of the five countries. The RONET[2] model will be used first to assess the difference in total network upgrading and maintenance costs without any LVSR upgrades, and second taking account of LVSR upgrades where these are the least cost option and where they are economically justified.

Choice of networks

In the technical proposal we suggested using a combination of the road networks described in report BP7 of the AICD Study (the networks used for the rural connectivity analyses of that Study) and national road agency network databases. Investigations made during the trial application of the proposed method indicated that the BP7 road networks are no longer accessible and so cannot be used (although summary data for the networks of each of the five countries (total lengths of each type of road surface and the lengths of earth and gravel road that would need to upgraded to sealed road status to meet different percentages of the Rural Accessibility Standard and Agricultural Production Standards) are available.

Instead we will focus on the national road networks and in particular on the earth and gravel roads that were included in the primary, secondary and tertiary road networks used in the road maintenance costs analyses described in BP14 of the AICD study. If more recent versions of these networks can be found in time, they will be used instead. The BP14 networks include 143,104km of unpaved roads in the five countries included in this Analysis, compared to only 37,336km (plus 192,784km of tracks) in the BP7 networks. Since it is much less likely that tracks will be upgraded to LVSR status than earth or gravel roads, and that tracks are not included in road networks that are the responsibility of the national road agencies, the lack of availability of the BP7 networks should not impact on the number and cost of links assessed to be upgraded, or on the estimated costs of maintaining the low volume sections of the road networks under the responsibility of the national road agencies.

Table 1 Length of unpaved roads in national classified road networks

Country	Primary kms	Secondary kms	Tertiary kms	Total kms
Ethiopia	821	4,513	10,595	15,929
Kenya	1,744	13,339	33,885	48,968
Malawi	958	6,270	3,051	10,279
Mozambique	549	4,020	18,959	23,528
Tanzania	3,713	20,687	20,000	44,400
Total	7,785	48,829	86,490	143,104

Source: AICD BP14, Table 4

Base case network analysis

The Stage Two network analyses will start with runs of the RONET model for the whole of the unpaved road network of each of the five countries, to give a base case for the net present value (NPV) of

[2] RONET User Guide, Version 2, January 2009 http://siteresources.worldbank.org/EXTAFRSUBSAHTRA/Resources/SSATPWP89A-RONET.pdf

upgrading and maintaining the networks. This analysis will also give the NPV of the road agency upgrade and maintenance costs and the same runs of RONET will give the asset value of the networks before and after upgrading with conventional paved surfaces.

RONET requires as an input the choice of a standard to which the road network will be maintained. While the preferred choice is to maintain to the highest economically justified standard, this usually involves a total cost that is beyond the financial resources of the agencies responsible for the networks. Since there will probably not be time to optimize the maintenance standard for each country that is compatible with its maintenance resources, we will start by using the less than ideal but financially feasible standards that emerged for each country from the AICD road maintenance cost assessment and reported in BP14.

LVPR network selection

We will use the parameters identified in Stage 1 for which LVSRs are the least cost option to select the links that have those characteristics in the national road network of each country

A problem with this approach became apparent during the trial application. The link data in the BP14 national road network databases for earth and gravel roads does not include their terrain type, climate type or traffic level, but it does include their GIS references. We will overlay digital terrain and climate maps on the digital network maps to determine the terrain and climate characteristics of each earth and gravel link in the network.

Traffic levels

GIS referencing cannot give traffic levels and these are necessary for selecting links for which upgrading will be justified, so another method of estimating current traffic levels.

RONET operates with nine predetermined traffic levels of which only four and possibly five are relevant to the upgrading of earth or gravel roads. So the estimates of traffic levels only need to be precise enough to allocate those of each link to one of the relevant four (T1 to T4) predetermined traffic levels (it is expected that LVSRs will be appropriate at the traffic levels indicted in RONET for "Gravel warranted" and perhaps for "Paved warranted" (RONET does not include a 1-lane gravel or paved surface as a warranted traffic level).

Table 2 RONET Traffic levels and indicative upgrading thresholds

	Average Annual Daily Traffic (AADT)			Illustrative Standards	
Traffic Level	Minimum (veh/day)	Maximum (veh/day)	Average (veh/day)	Geometry Standard	Pavement Standard
T1	0	10	5	1-lane warranted	Formation not warranted
T2	10	30	20	1-lane warranted	Formation warranted
T3	30	100	65	2-lane warranted	Gravel warranted
T4	100	300	200	2-lane warranted	Gravel warranted
T5	300	1,000	650	2-lane warranted	Paved Surface warranted
T6	1,000	3,000	2,000	2-lane warranted	Paved Surface warranted
T7	3,000	10,000	6,500	2-lane warranted	Paved Surface warranted
T8	10,000	30,000	20,000	4-lane warranted	Paved Surface warranted
T9	30,000	100,000	65,000	multi-lane warranted	Paved Surface warranted

Source: RONET User Manual, 2009 Table 3

If the proposed field visit is authorized, subjective estimates of the traffic levels will be obtained from the local road engineers for selected regions in the two countries selected. Local road engineers often have a good knowledge of traffic levels on unpaved roads. If the field visit is not authorized we will attempt to estimate traffic levels using the BP14 analysis or even use BP 7 upgrades based on connectivity rather than traffic level standards, but so far we have not been able to recover the network data to do this.

Total network costs with LVSR upgrading

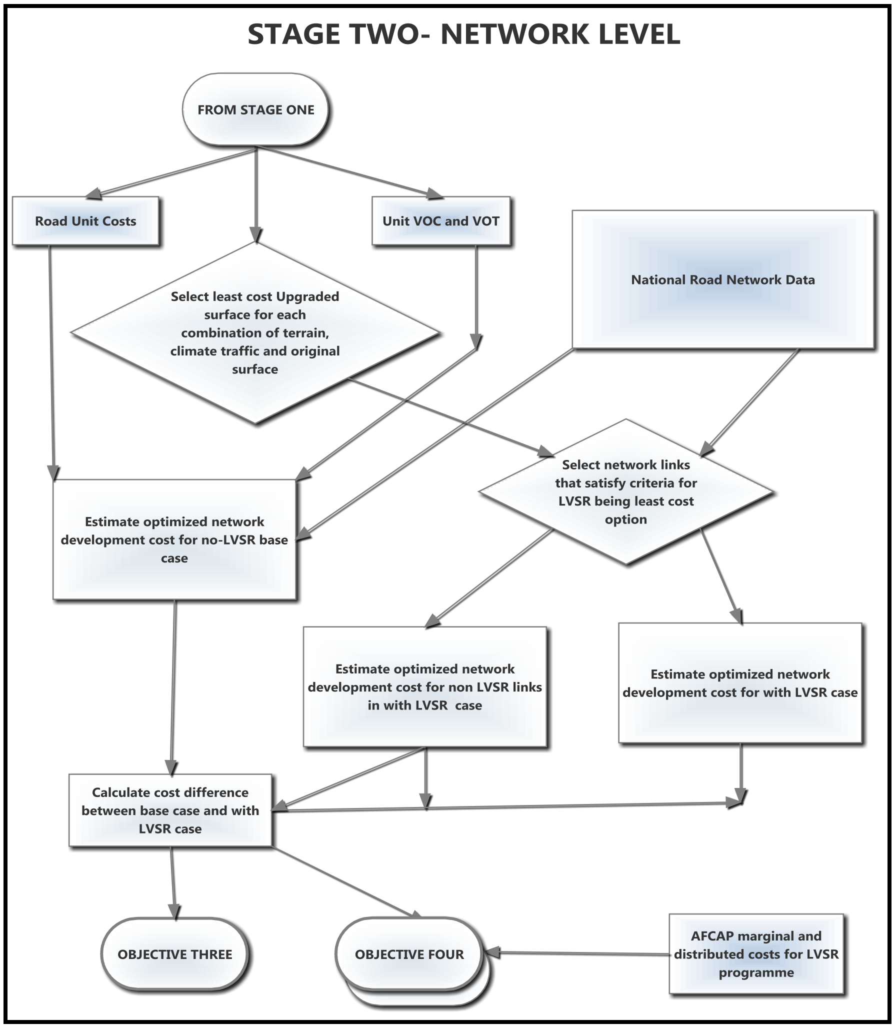
Once the subset of the road network for which LVSRs would be the most appropriate upgrade option has been extracted, we will run RONET for this reduced network to see which of these links actually justify upgrading using the RONET criteria. Not all the RONET determined upgrades will involve LVSR upgrades, as some might be for gravel or single surface treatment upgrades, but we will be able to separate the costs for the LCSR upgrade sections from the others. We can determine the net present value of costs and benefits and net benefits of the justified LVSR upgrades and maintaining costs for this subset of the network to the same maintenance standard as was assumed for the whole network in the base case.

We will also run RONET for the residual network in each country (the whole network less the "potential LVSR network") and determine its upgrade and maintenance costs and benefits using the same RONET criteria. When the NPVs for these residual networks are added to those of the "potential LVSR" networks we will have the NPVs for the whole network in each country, taking account of the LVSR upgrades (the 'combined network'). This summation will also allow estimation of the agency upgrade and maintenance costs and net present values of net annual benefits and overall network asset values.

Assessment of LVSR benefits at the network level

For each country, the difference between the NPV and AAC of the base case network and that of the combined network will be the measure of the benefits of applying the LVSR approach on a network basis for each country (Objective 3).

We will use the same data to estimate the chance in asset value of the national road networks if all the relevant links are upgraded using LVSR methods, and also to estimate the economic rates of return of the LVSR investments, and as in the previous assessment of Mozambique, indicate the share (in kms and %) of each national network for which an LVSR approach would be the most appropriate and economically justified.



Value for Money analysis of AFCAP research inputs

The sum of the differences in network costs over all five countries will be a first measure of the overall benefit of the LVSR approach. It will be necessary to modify the total NPV as it is unlikely that the LVSR approach will be adopted instantly in its entirety by all five countries. As been apparent over the last decade or so, despite the apparent advantages of an LVSR approach, there is strong resistance to its full implementation. We will make a subjective assessment of how quickly each country might implement the approach, given the additional evidence of its merit that Is expected to come from this Analysis, and estimate a revised five country total NPV.

There are two components of the cost of this research under this part of the AFCAP programme. First is the cost to AFCAP, which in itself has two parts, the direct research costs and the share of the fixed costs of the overall AFCAP programme (the first is the marginal cost and the second is the fully distributed cost), and both are relevant in assessing the benefits of this part of the programme. The second component is the cost incurred by the countries themselves in adopting the LVSR approach. There will be training costs for design engineers, contracting companies and supervising engineers to learn how best to implement LVSR methods, as the expected benefits in terms of reduced maintenance costs and longer lives compared to alternative conventional methods depends very much on how well the LVSR roads are constructed in the first place.

The value for money of the AFCAP Programme will use three performance criteria:

a straightforward discounted cash flow of costs (both components measured in constant financial costs); a net present value of the economic costs and benefits (using the difference in npv of the road network investments without and with LVSR roads (less the staff and contractor training costs) as the measure of benefit) and the annual investment costs of the AFCAP as the costs. A check will be made replacing the change in the net present values of the asset values of the road networks as an alternative measure of benefit All measures of costs and benefits will be in economic costs, based on adjusted financial costs by eliminating transfer and other non-resource costs (we will not adjust prices for distortions from border prices or labour rates allowing for distortions to market rates – both of these are very time consuming and notoriously unreliable).
an economic rate of return using the same economic costs as used to derive the npv of economic costs and benefits.

3. Data consideration for the use of RONET

For RONET to operate as intended it needs more detail on road surfaces, their condition and traffic levels than is currently available. The following example (for Mozambique) illustrates the level of detail available from the AICD Study that was focused on the primary and secondary networks. For the application of RONET to the rural roads of the five countries, a similar level of detail will be required to complement this data with that of the tertiary networks, where most of the unpaved roads are categorized. For the AICD Study an extensive field work exercise was needed to obtain sufficiently reliable data for the primary and secondary networks. For this Study to have comparable reliability in its findings, similar but less extensive field work will need to be carried out, to obtain the information directly from road engineers of the road agencies that know the basic characteristics of their rural networks.

Table 3 Example of distribution of road traffic between traffic levels for different road classifications and surface conditions

Primary
S.T.

Condition (IRI) / Traffic (AADT)		Very Good	Good	Fair	Poor	Very Poor
		2	3	4	8	12.0
Traffic I	100-300	73	538	705	159	0.0
Traffic II	300-1000	525	232	283	17	0.0
Traffic III	1000-3000	302	618	292	104	88.0
Traffic IV	3000-10000	0	34	0	0	0.0
Traffic V	10000-30000	0	0	0	0	0.0
						3,970.1

Primary
Gravel

Condition (IRI) / Traffic (AADT)		Very Good	Good	Fair	Poor	Very Poor
		5	7	11	16	20.0
Traffic I	10-30	6	70	19	33	0.0
Traffic II	30-100	19	69	49	45	0.0
Traffic III	100-300	21	69	68	43	0.0
Traffic IV	300-1000	14	7	15	2	0.0
Traffic V	1000-3000	0	0	0	0	0.0
						549.0

Secondary
S.T.

Condition (IRI) / Traffic (AADT)		Very Good	Good	Fair	Poor	Very Poor
		2	3	4	8	12.0
Traffic I	100-300	41	0	448	114	28.2
Traffic II	300-1000	0	19	22	44	0.0
Traffic III	1000-3000	128	3	24	0	0.0
Traffic IV	3000-10000	8	0	0	0	0.0
Traffic V	10000-30000	0	0	0	0	0.0
						879.6

Secondary
Gravel

Condition (IRI) / Traffic (AADT)		Very Good	Good	Fair	Poor	Very Poor
		5	7	11	16	20.0
Traffic I	10-30	0	65	55	45	0.0
Traffic II	30-100	0	670	1,181	286	167.0
Traffic III	100-300	0	72	0	0	0.0
Traffic IV	300-1000	63	0	0	0	0.0
Traffic V	1000-3000	0	0	0	0	0.0
						2,604.0

Source: Application of RONET model to Mozambique for the AICD Study

4. Commentary on other technical points

i.	Cost adjustments	No change to Technical Proposal
ii.	Traffic growth rates	No change to Technical Proposal

iii. AFCAP costs — No change to Technical Proposal but see comment above under Value for Money analysis

iv. Sensitivity tests — The Monte Carlo method will not be used as it is very time consuming to make all the RONET runs needed and experience shows that little attention is given to its results. Instead more attention will be given to assessing the probabilities of the switching values

v. Road accident costs — No change to Technical Proposal, but during the trial analysis no specific data on road accident (fatality) rates on LVSR roads could be found. Without this data the accident (fatality) analysis cannot be made. We will rely on AFCAP for this data as the most comprehensive source for LVSR data.

Choice of LVSR method — The particular type of LVSR that is most suited to each network link depends very much on local conditions, particularly the availability of materials, the characteristics of those materials, the experience of local highway engineers and contractors in using a particular method, and the local micro-climate. The objectives of this study do not include selecting the most suitable LVSR method for each circumstance. The main objective is to determine in more general terms whether LVSR methods as an entirety

5. Sub contracted consultant

The revised approach will require at least 12 runs of the ROCKS, RUCKS and RED models for Stage 1 and at least 15 (3 for each country) runs of the RONET model for Stage 2, and an estimated 20 more (four for each country) runs of RONET for the sensitivity tests, these mostly to determine the switching levels of the key variables. The way that RONET is set up is not the most convenient for the type of analyses we are proposing, since it does not include any LVSR surface types so the data for these will first have to be generated and then substituted in the model for road types that will not be used (such as asphaltic pavements).

For the final report to be delivered close to the original scheduled date it will be necessary for many activities to be undertaken in parallel (see Table 2) and this will not be possible unless another consultant is sub-contracted.

For these reasons we propose to sub-contract a consultant who has substantial experience in the development and use of ROCKS, RUCKS and RONET models and the application of HDM-4 and RED models. With this experience, in particular knowledge of the inner workings of RONET and how it can best be adjusted and run for the purposes of this Analysis, it will be possible to undertake the runs of the model more quickly and more reliably. In addition, the selected consultant was responsible for the field work in collecting data for the operation of RONET for the AICD BP14 analysis, and so will be experienced and efficient for the field work proposed in the next section.

The tasks of the sub contracted consultant will be to prepare the inputs to the RONET model and to run the model as specified by the lead consultant, but also to advise that consultant on how best the model can be used to achieve the objectives of the Analysis using the approach described in this Inception Report.

The proposed consultant would be sub-contracted at the same daily rate as the lead consultant (£600 per day including liability for taxes) on a formal contract, with the inputs and outputs and number of days of work specified (probably between 20 and 25, but depending on the negotiated tasks to be undertaken, and with an addition should the proposed field mission be authorized). The sub contacting of itself will neither reduce nor increase the number of days or cost of the contact, but will greatly

increase the quality and reliability of the output of the model and the conclusions of the Analysis that are based on those outputs.
The CV of the proposed consultant is attached as an Annex to this Inception Report.

6. Proposed field mission

In the Comments on the TORs included in the Technical Proposal we indicated that the time available for the Analysis could prejudice the quality of the results. On the basis of experience in the trial application we confirm this assessment. Our proposal to remedy this problem is to extend the period allowed for the Analysis by a minimum of three weeks, which would allow for a field mission of two weeks to collect data that is either not available (such as traffic levels on unpaved roads) or not sufficiently reliable (such as the construction and maintenance costs of unpaved roads).
To make the simplified analysis this basic cell data and the multipliers as reliable as possible, we propose that a two week mission to two countries (although a three week mission to three countries would be even more useful) be undertaken to learn from practiced field engineers the particular costs for the four surface types and vehicle operating costs in their country and region. Without this field visit we will rely on data already in the models, and experience on the costs of LVSRs available from within the five countries. Most of already available data was collected during the field visits made during the work for the road maintenance cost analysis for the AICD Road Maintenance Cost assessment. However, those field visits focused on data for road maintenance and not upgrading and on the primary and secondary and not tertiary road networks.

7. Revised schedule of activities

The revised schedule of activities is shown in Table 4. It indicates that even with working over the holiday period it will not be possible to submit the final report before February 8th, 2013 and this conclusion is based on a very tight timetable with no allowances for unforeseen problems.

Table 4 Detailed Work Program

Activity	21/12	28/12	4/1	11/1	18/1	25/1	2/1	8/2
Stage 1								
Data collection								
Basic unit costs of Gravel, and SST flat terrain and dry climate	X							
Data for life cycle costs of LVSR and deterioration curves	X							
Basic unit costs for LVSR flat terrain and dry climate	X							
Multipliers for other terrains and climates		X						
Basic VOC and VOT for G,SST and DST flat terrain and dry climate		X						
Multipliers for other terrains and climates			X					
AFCAP project costs			X					
Analysis								
Estimate of life cycle costs of LVSR using the RED Model			X	X				
RED model for upgrading earth and gravel roads to LRSV				X				
Assessment of parameters when LVSR are best option			X					
Evaluation of LVSR upgrading of earth and gravel roads					X			
Reports								
Stage 1 Report			X	X	X			
Stage 2								

Data collection					X			
AFCAP project costs			X	X				
Macro-economic data for 5 countries	X							
National road networks	X	X	X	X				
Site visit								
Analysis								
RONET Model for 5 countries without LVSR roads				X				
Selection of network links that meet criteria for LRSV upgrades					X			
RONET model with potential LVSR links only					X			
RONET model with non-LRSV only						X		
Estimate difference between without and with LVSR network						X		
Estimate value for money of AFCAP investment							X	
Reports								
Final Report					X	X	X	X

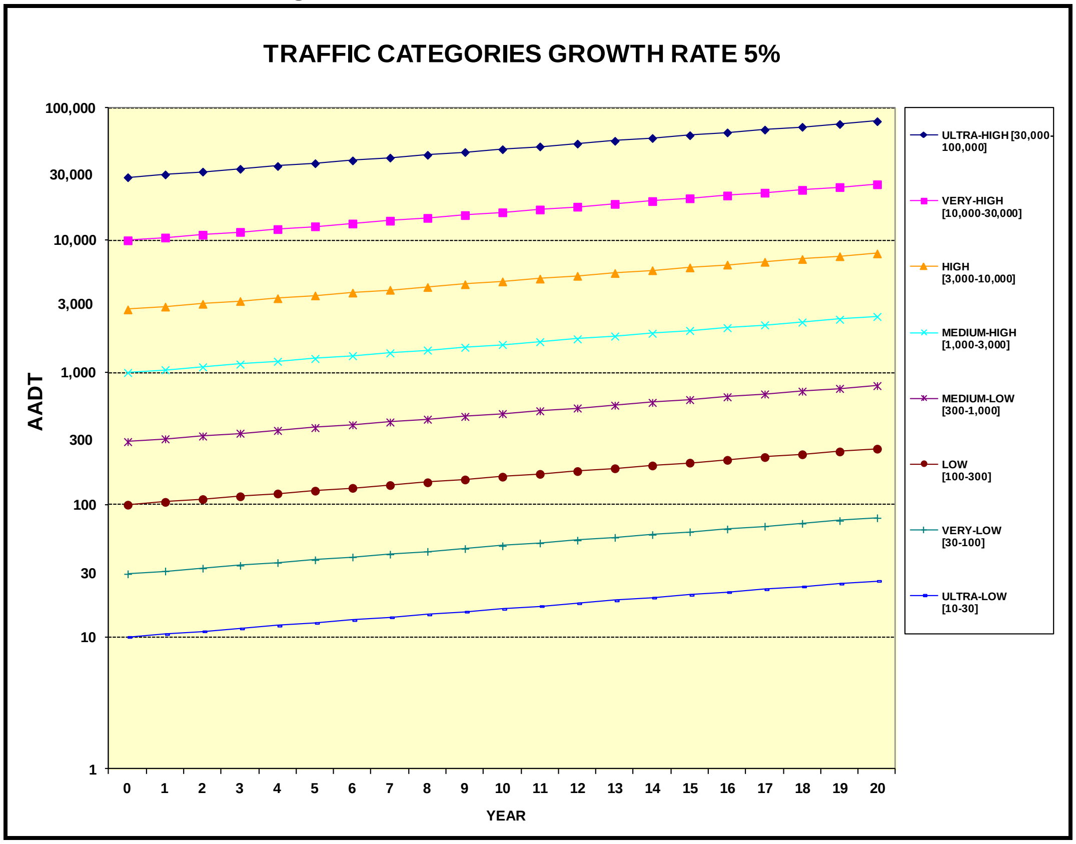
If the proposed field mission is accepted, the final report would be submitted three weeks later, that is on March 1st, 2013. An interim report on the Stage 1 analyses will be submitted on January11th, although it will be drafted as the analyses are progressing. Most of the Stage 2 data collection will be undertaken while the Stage 1 analyses are under way and the Stage 1 Interim Report is being written. These simultaneous activities will only be possible if the proposal for sub-contracting another consultant is accepted. If this is not accepted, the final report could not be submitted before the end of February.

Annex 1 Some examples of trial analyses using the RED and RONET models

In this Annex we show some of the input data to the trial applications of the four road analysis models that will be used in Stages 1 and 2 of the analysis

i. Traffic categories and traffic growth rates for use in RED in Stage 1

The RED model as used in Stage 1 will address only two traffic categories; (i) a very low traffic level of 30-100 AADT and a slightly higher level of 100-300 AADT at which more links are likely to be economically justified in the Stage 2 runs of the RONET model . The following figure shows that a plausible annual traffic growth rate (5%) is unlikely to move the traffic level of any link from one of the predetermined traffic level categories to another.



ii. Data inputs to ROCKS U$) for estimation of life-cycle costs in Stage 1

The life cycle costs of earth, gravel and single surface treatment roads have already been estimated using average unit costs for a selection of Sub-Saharan African countries. These life cycle cost estimations should be repeated using unit costs application to each one of the five countries and extended to cover LVSRs.

Capital Road Works Unit Costs			
Surface Type	Current Condition	Road Work	Tertiary
Surface Treatmeant	Good Condition	Preventive Treatment	1,200
	Fair Condition	Resurfacing (Reseal)	10,800
	Poor Condition	Strengthening (Overlay)	54,000
	Very Poor Conditio	Reconstruction	108,000
	No Road	New Construction	180,000
Gravel	Good Condition	Spot Regravelling	1,800
	Fair Condition	Regravelling	6,600
	Poor Condition	Partial Reconstruction	10,500
	Very Poor Conditio	Full Reconstruction	21,000
	No Road	New Construction	36,000
Earth	Good Condition	Spot Repairs	90
	Fair Condition	Heavy Grading	300
	Poor Condition	Partial Reconstruction	4,500
	Very Poor Conditio	Full Reconstruction	9,000
	No Road	New Construction	24,000

Recurrent Maintenance Works Unit Costs			
Surface Type	Road Condition	Road Work	Tertiary
Surface Treatment	Very Good	Recurrent Maintenance	500
	Good	Recurrent Maintenance	625
	Fair	Recurrent Maintenance	750
	Poor	Recurrent Maintenance	875
	Very Poor	Recurrent Maintenance	1,000
Gravel	Very Good	Recurrent Maintenance	250
	Good	Recurrent Maintenance	313
	Fair	Recurrent Maintenance	375
	Poor	Recurrent Maintenance	438
	Very Poor	Recurrent Maintenance	500
Earth	Very Good	Recurrent Maintenance	125
	Good	Recurrent Maintenance	157
	Fair	Recurrent Maintenance	188
	Poor	Recurrent Maintenance	219
	Very Poor	Recurrent Maintenance	250

iii. Data required to derive vehicle operating costs using RUCKS

The unit costs and vehicle utilizations shown in this table are averages for all Sub-Saharan African countries. More reliable conclusions will be reached if unit costs and utilizations applicable to each one of the five countries can be obtained from the proposed field study, of if country scaling factors can be estimated from other sources.

Vehicle Description (text)	Economic Unit Costs ($) New Vehicle ($/vehicle)	New Tire ($/tire)	Fuel ($/liter)	Lubricating Oil ($/liter)	Maintenance Labor ($/hour)	Crew Wages ($/hour)	Annual Overhead ($/year)	Annual Interest (%)	Passenger Working Time ($/hour)	Passenger Jon-Workin Time ($/hour)	Cargo Time ($/hour)
Motorcycle	2,000	20	0.39	2.30	1.18	0.40	26.00	12	0.60	0.20	0.00
Car Small	10,000	40	0.39	2.30	2.14	0.45	40.00	12	0.60	0.20	0.00
Car Medium	15,000	60	0.39	2.30	3.68	0.52	69.00	12	0.60	0.20	0.00
Delivery Vehicle	17,000	70	0.39	2.30	4.91	2.76	71.00	12	0.60	0.20	0.00
Four-Wheel Drive	20,000	80	0.38	2.30	3.84	0.46	100.00	12	0.60	0.20	0.00
Truck Light	30,000	120	0.38	2.30	4.78	1.07	138.00	12	0.38	0.11	0.11
Truck Medium	70,000	250	0.38	2.30	4.78	2.00	138.00	12	0.38	0.11	0.11
Truck Heavy	110,000	290	0.38	2.30	5.37	3.67	280.00	12	0.38	0.11	0.11
Truck Articulated	140,000	290	0.38	2.30	5.82	3.67	280.00	12	0.38	0.11	0.11
Bus Light	30,000	70	0.38	2.30	5.41	3.15	177.00	12	0.38	0.11	0.00
Bus Medium	45,000	110	0.38	2.30	5.41	1.88	177.00	12	0.38	0.11	0.00
Bus Heavy	70,000	215	0.38	2.30	5.41	1.88	208.00	12	0.38	0.11	0.00

Vehicle Description (text)	Basic Vehicle Fleet Characteristics Annual km Driven (km)	Annual Working Hours (hours)	Service Life (years)	Private Use (%)	Numbe of Passengers (#)	Work Related Passengers Trips (%)	Gross Vehicle Weight (t)
Motorcycle	15,000	700	9	100	1	75	0.3
Car Small	22,000	800	9	100	2	75	1.1
Car Medium	24,000	880	9	100	3	75	1.6
Delivery Vehicle	40,000	1,300	9	0	3	0	2.3
Four-Wheel Drive	34,000	1,200	9	0	2	0	2.0
Truck Light	59,000	1,500	9	0	1	0	4.6
Truck Medium	67,000	2,200	9	0	1	0	13.9
Truck Heavy	69,000	2,300	10	0	1	0	28.2
Truck Articulated	65,000	2,400	9	0	1	0	36.5
Bus Light	76,000	1,800	7	0	11	75	2.6
Bus Medium	90,000	2,800	6	0	30	75	5.0
Bus Heavy	103,000	2,700	10	0	42	75	11.9

Vehicle Fleet Unit Road User Costs Relationship to Roughness

Unit Road User Costs ($/veh-km) = a0 + a1*IRI + a2*IRI^2 + a3*IRI^3

Traffic Level	T3	T4
AADT	50	200
a0 coefficient	0.22212	0.22212
a1 coefficient	-0.00162	-0.00162
a2 coefficient	0.00115	0.00115
a3 coefficient	-0.00003	-0.00003

iv. Data required to apply RED

In Stage 1 of the analysis only two of the nine cells of the typical 3 x 3 matrix of road terrain and climate conditions will be assessed in detail for the costs of upgrading and maintenance, the assessments of the other cells to be obtained using row and column scaling factors. The two situations to be analyzed in detail are those of upgrading an earth road in very poor condition with 50 AADT and upgrading a gravel road in very poor condition with 200 AADT

Class Surface	TRAFFIC CATEGORY (AADT)			
	ULTRA-LOW [10-30]	VERY-LOW [30-100]	LOW [100-300]	MEDIUM-LOW [300-1,000]
EARTH	NO	YES	NO	
GRAVEL		NO	YES	NO

Note: NO To Exclude and **YES** to Include in the Lifecycle Cost Analysis

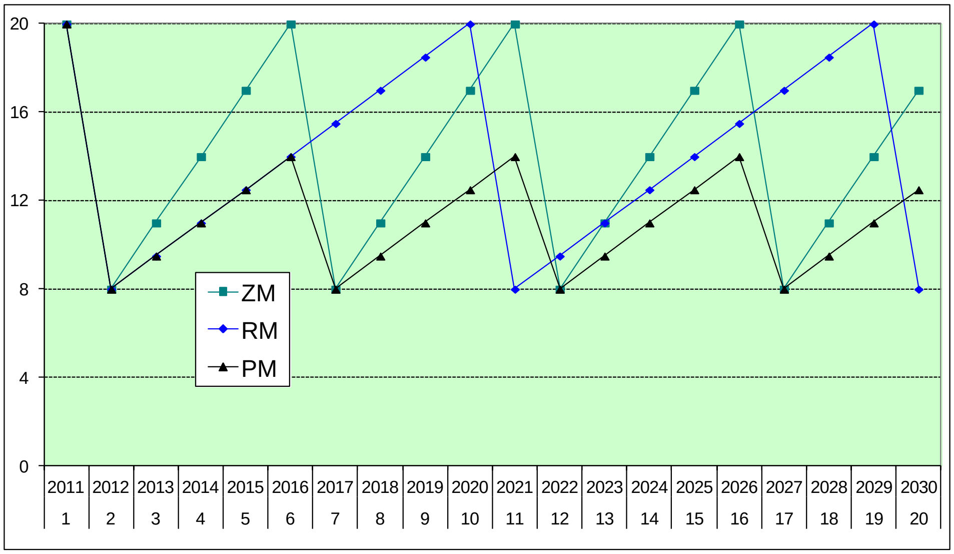
	Existing Road Type ⟶	Earth Road 50 AADT	Gravel Road 200 AADT
SURFACE CLASS	**SURFACING CATEGORY**	**Surfacing Type Alternatives**	
UNSEALED	**EARTH**	**LVSR**	
		Gravel Road Surface [GRS]	
		Single Surface Treatment [SST]	
	GRAVEL		**LVSR Otta Seal [OTS]**
			Gravel Road Reconstruction [GRR]
			Single Surface Treatment [BDS]

AFCAP SELECTED CASE STUDY SCENARIOS		
CASE STUDY SCENARIO	CSS1 EARTH	CSS2 GRAVEL
SURFACE CLASS	Earth Road	Gravel Road
SURFACE CLASS	VERY LOW	LOW
TRAFFIC CATEGORY	[30-100]	[100-300]
AADT	50	200
ROAD CLASS	TERTIARY	TERTIARY
NUMBER OF LANES	2L	2L
CARRIAGEWAY WIDTH [M]	4.2	4.2
ROAD CONDITION	VERY POOR	VERY POOR
	POOR	POOR
	FAIR	FAIR
	GOOD	GOOD
	VERY GOOD	VERY GOOD
TERRAIN TYPE	FLAT	FLAT
	ROLLING	ROLLING
	MOUNTAINOUS	MOUNTAINOUS
MODEL	RED	RED
LIFECYCLE PERIOD [YEARS]	20	20
ANNUAL TRAFFIC GROWTH RATE	5%	5%
ROAD SECTION LENGTH [KM]	10	10
CLIMATE A	Semi-Arid / SubTropical Hot	Semi-Arid / SubTropical Hot
CLIMATE B	Sub-Humid / Sub Tropical Hot	Semi-Humid / Sub Tropical Hot
ALTERNATIVE 1 [BASE]	Gravel Surfacing 150 mm	Gravel Reconstruction 150 mm
ALTERNATIVE 2	Single Surface Treatment 15 mm	Single Surface Treatment 15 mm
ALTERNATIVE 3	Single Otta Seal 15 mm	Single Otta Seal 15 mm
AVERAGE ANNUAL DAILY		
AADT	30	100
AADT	40	150
AADT	50	200
AADT	60	220
AADT	70	240
AADT	80	260
AADT	90	280
NMT AADT	0	0
ANNUAL TRAFFIC GROWTH RATE	7%	7%
	6%	6%
	5%	5%
	4%	4%
	3%	3%
TRAFFIC COMPOSITION		
LIGHT TRAFFIC	73%	65%
HEAVY TRAFFIC	27%	35%

For the gravel road, the trial evaluation assumed a 150 mm gravel surface with a deterioration progression over 20 year period and a 200 AADT traffic level

	CASE STUDY SCENARIO AFCAP CSS 2 Tertiary Gravel 200 AADT
ROAD CLASS	TERTIARY
NUMBER OF LANES	2
CARRIAGEWAY WIDTH [m]=	4.2
ROAD CONDITION:	VERY POOR
TERRAIN TYPE:	ROLLING
CLIMATE TYPE:	SUB-HUMID SUB-TROPICAL HOT
MOTORIZED TRAFFIC AADT [vpd]=	200
LIGHT TRAFFIC=	65%
HEAVY TRAFFIC	35%
ANNUAL TRAFFIC GROWTH RATE=	5%

The resulting life cycle of costs would be as shown in the following figure



20
16
12
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4
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ZM
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2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Annex 2 CV of proposed sub contacted consultant

Curriculum Vitae

ALBERTO F. NOGALES

Date of Birth: April 9, 1962
Address: 224 Lynn Manor Drive
Rockville, Maryland 20850, USA
Telephone: (202) 257 – 8726
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EDUCATION:

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, M.I.T.
Cambridge, Massachusetts, U.S.A. *09/88 - 05/89*
Special Program for Urban and Regional Studies (SPURS) Fellow
Emphasis in Developing Countries. Courses and Research in Urban Planning, Infrastructure, National Urban Policies, Regional and Local Governments, Business, Economics, and Computer Applications.

STANFORD UNIVERSITY
Stanford, California, U.S.A. *01/87 - 06/88*
Civil Engineering Department. Master of Science. Land Use Planning
Courses and Research in Resources Planning, Civil Engineering, Environmental Engineering, Construction Management, Computer Science, and Applications of Personal Computers. Emphasis in Land Use Planning.

UNIVERSITY OF CALIFORNIA LOS ANGELES, U.C.L.A.
Los Angeles, California, U.S.A. *09/86 - 12/86*
Certificate Program in Engineering Management for Construction
Courses: Construction Management, Pricing, Bidding and Estimating. G.P.A. 4.0/4.0

ESCUELA DE INGENIERIA MARISCAL SUCRE, E.M.I.
La Paz - Bolivia *02/81 - 12/85*
B.Sc. Civil Engineering. (Licenciatura)
Courses: Transportation, Structures, Hydraulics, Geotechnics, Construction, Soil Mechanics, Economics, and Cost Estimating. Ranked third in Graduating Class

EMPLOYMENT:
THE WORLD BANK *10/99 – Present*
IBRD ***Transport and Urban Development - Consultant***
Washington, D.C., U.S.A.
Presently working with the Independent Evaluation Group (**IEG**) on the Evaluation of the 2001-2011WBG Transport Sector Portfolio. Prepared 4 Case Studies on Transport Sector Sustainability for Nigeria, Senegal (field-based), Uganda & Tanzania (desk-based), a Note on Road Maintenance, and ICR Review for the Lagos Urban Transport Project. In the Africa Sustainable Development Department (**AFTSN**) developed a set of

Road Sector Indicators for 40 Sub-Saharan African countries (using RONET) as part of the Africa Infrastructure Country Diagnostic Study (AICD). Co-Author of the AICD 2011 Africa's Transport Infrastructure Publication. Transfered the AICD methodology & database to the African Dev. Bank (AfDB) Africa Infrastructure Knowledge Program (AIKP). Prepared Road User Costs estimates for Congo Republic, DRC, Liberia, Ghana & Mozambique. For the **AFTTR** (Africa Transport) prepared an ICR of a railways concession transport project in Zambia.

Worked with the transport unit in East Asia (**EASTR**) on the preparation of three highway projects in China (Jiangxi III, Fujian III, and Shaanxi III); two ICRs in China (NH4) and one for Indonesia; and in **LCRFT** (Transport Latin America) on an ICR for a highway project in Bolivia. In (**EASUR**) participated in the identification of a cross-sectoral Regional Development Project in Indonesia (Yogyakarta), drafting two ICRs of highways projects in China (**EASTR**), and yet another

In the **Transport Unit of the East Asia and the Pacific Region (EASTR)** worked with the task teams:

(i) drafting four Transport Sector Briefs: China, Lao, Vietnam and Indonesia. These are ten-page documents that identify issues, propose policy recommendations and provide basic transport sector data for all modes: highways, railways, waterways, air transport and inter-island shipping;
(ii) drafting sector work in Papua New Guinea to analyze the transport sector investment as a percentage of GDP and as a percentage of public expenditure;
(iii) preparing four Implementation Completion Reports (ICRs). The Luang Namtha Provincial Development Project in Lao PDR, the Pusan Urban Transport Project in Korea, the Third Highways Improvement Project in Lao PDR, and the Highways Project in Vietnam (rated exemplary by OED);
(iv) in Vietnam, preparing the Road Network Improvement Project; and reviewing the procurement process for large civil works construction projects for the Mekong Transport and Flood Protection Project;
(v) in Laos, preparing the Operation Manual for the implementation of a Japanese Social Development Fund (Grant) to establish an institutional framework for rural road maintenance with community participation; and
(vi) in China, analyzing cost estimates and contingency allowances for 25 Bank-financed highway projects covering a 15-year period.

For the **Procurement Policy and Services Group (OPCPR).** Successfully completed the report on: "Distribution by Supplier Country of Major Civil Works, Goods and Consulting Contracts awarded under World Bank-Financed Projects". This five-year period (July 1996 – June 2001) analysis of a total of amount of US$48 billion, included all countries worldwide and all sectors.

In the **Transport and Urban Development Division (TUDTR**) worked on the development and implementation of the Road Costs Knowledge System (**ROCKS**) that provides a framework to collect, and analyze road costs databases worldwide. Conducted missions to South Asia and East Asia & Pacific Regions (Bangladesh, India, Thailand, Vietnam, and Philippines); Africa (Ghana and Uganda); and Eastern Europe (Poland and Armenia). Translated the system to Spanish and conducted a training seminar for Bank-staff on the applications of the system. Completed the analysis of road works costs in Guatemala for the Inter-American Development Bank. In TUDTR: (i) revised and updated the Roads and Highways knowledge node, and prepared the Consultations of the Urban Transport Strategy Review; (ii) evaluated the road safety components of the transport portfolio; (iii) conducted research and prepared a Draft Note on the links between HIV/AIDS and Transport, (iv) participated in a team to prepare a proposal to provide TA for implementing toll roads in Saudi Arabia; and (v) regularly assisted with data collection, analysis, research, and preparation of presentations for the staff in TUDTR.

In the **South Asia Infrastructure Unit (SASIN)**:
(i) provided cross support to emergency operations (El Nino) for Bolivia with the appraisal of a housing program, and on procurement issues in Paraguay and Perú;
(ii) worked closely with the Task Manager of the Tamil Nadu Urban Development Project in India, and the implementation of City Development Strategies (CDS); and
(iii) participated in the preparation of the Third National Highways Project for India.

THE WORLD BANK *02/95 – 9/99*
IBRD-IDA ***Infrastructure and Urban Development Project Officer***
La Paz - Bolivia
In the field in the Bank Resident Mission in Bolivia I worked closely with the clients in the identification, preparation, supervision, and evaluation of transport and urban development projects. Some of the experiences I had during this assignment include:

(i) participation in the preparation of a large portfolio of road construction and maintenance programs, and contribution to the analysis of the road sector policies and definition of a long term investment plan;

(ii) direct involvement in the inception and implementation of the Comprehensive Development Framework (CDF) and CAS in Bolivia, and fully familiar with Poverty Reduction Strategy Plans (PRSPs) and programmatic lending; and

(iii) Acting Resident Representative several times and for extended periods that provided me with general overall experience in Bank field office administration and management.

CENTRO DE SERVICIOS INTEGRADOS PARA EL DESARROLLO URBANO
PROA *09/92 - 01/95*
La Paz - Bolivia ***Housing Program Officer***
Non-Profit Development Organization.

Responsible for the preparation, management, and evaluation of all Urban Housing Programs. In charge of the housing credit program called "PROCASA" that provided and recovered housing loans for low income families in the city of El Alto. More than 1,500 families benefited from about US$2 million obtained from commercial Banks and Mutual Funds.

MINISTRY OF URBAN AFFAIRS - PLAN NACIONAL VIVIENDA POPULAR
IREC/EPFL-COTESU-Switzerland *01/91 - 12/92*
La Paz - Bolivia ***Researcher and Coordinator***
Swiss-Bolivian Scientific Cooperation. Coordinated the activities between the Ministry of Urban Affairs of the Bolivian Government, and the "Institut de Recherché Sur l'Environment Construit of the Ecole Polytechnique Federale de Laussane, IREC/EPFL - Suisse". Participated in the Research Program to support the implementation of the National Housing Plan for low income families.

EL ALTO URBAN DEVELOPMENT PROGRAM
PROA/USAID/Bolivia *11/89 - 12/90*

La Paz, Bolivia ***Urban and Regional Planning Specialist***
USAID Project.
Managed the Solid Waste Collection and Transport System Projects for the cities of El Alto, La Paz and Trinidad, Beni. Coordinated the Forestation Plan for the city of El Alto, and the activities of the Forestation Coalition (COAFOR), and the Forestation Financing Fund (FoFiFo). Studied and collected data to establish a Free Trade Zone in the city of El Alto. Responsible for preparing and developing Urban Development Innovation Projects.

THE WORLD BANK, IBRD *05/89 - 09/89*
Washington, D.C., U.S.A. ***Research Assistant***
UNDP-World Bank Water and Sanitation Program.
Worked with the Water and Sanitation Division and the Urban Development Department for the International Drinking Water Supply and Sanitation Decade (1981-1990). Developed a Case Study to analyze a pilot project in Bogota, Colombia to implement Simplified Sewerage Systems in Latin America. Developed a computer system to identify the sources of finance, the resource allocation, the scheduling of activities, and to monitor the implementation of projects in the Regional Water and Sanitation Groups in the field.

INTER-AMERICAN DEVELOPMENT BANK, IDB *07/88 - 09/88*
Washington, D.C., U.S.A. ***Urban Development Projects Research Assistant***
International Development Assistance Organization.
Reviewed and studied technical parameters of urban development projects in Latin-America and the Caribbean, financed by the Inter-American Development Bank. Participated in an official mission to Mexico City to coordinate and negotiate the preparation of a national municipal development project. Developed a computer application to effectively monitor the preparation of urban development projects, and to coordinate and plan the scheduling of missions for the professional staff of the Social Development Division of the Bank.

HONORS:

SPURS Fellow, Massachusetts Institute of Technology, M.I.T.
Organization of American States Fellowship, O.A.S.
International Rotary Club Scholarship.

LANGUAGES:

Spanish (native), English (fluent).

PUBLICATIONS:

- With Ken Gwilliam, Vivien Foster, Cecilia Briceno, H. Bofinger, R. Bullock, R. Carruthers, A. Kumar, M. Mundy, and Kavita Sethi – "Africa Transport Infrastructure: Mainstreaming Maintenance and Management", Africa Infrastructure Country Diagnostic (AICD) – 2011.
- With Rodrigo Archondo-Callao and Anil Bhandari –Road Cost Knowledge System– Sixth International Conference on Managing Pavements – Brisbane, Australia – October 2004.
- For the Transport Sector Unit of the East Asia and Pacific Region – EASTR: Transport Sector Brief China – April 2004. Transport Sector Brief Lao PDR – May 2004. Transport Sector Brief Vietnam–June 2004. Transport Sector Brief Indonesia–June 2004.

- With Graham Smith the Article "China's Evolving Transportation Sector" – The China Business Review Magazine – Volume 31 Number 2 – March-April 2004.
- Aplicación del Sistema ROCKS para el Análisis de Costos de Obras Viales Financiadas por el BID en Guatemala – Dirección General de Caminos – Noviembre 2003.
- Distribution by Supplier Country of Major Civil Works, Goods and Consulting Contracts awarded under World Bank-Financed Projects – Period July 1996 – June 2001 – Procurement and Policy Services Group – OPCPR – October, 2003.
- With Rodrigo Archondo and Anil Bhandari – Road Costs Knowledge System – ROCKS Final Report – Transport and Urban Development Department – TUDTR – June 2002.