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IMPROVING THE SUSTAINABILITY OF ROAD MANAGEMENT AND FINANCING IN ARMENIA

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Abbreviations and Acronyms

AADT	Average Annual Daily Traffic
ADB	Asian Development Bank
ARD	Armenian Road Directorate
EBRD	European Bank for Reconstruction and Development
ECA	Europe and Central Asia
EU	European Union
FWD	Falling Weight Deflectometer
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GIS	Geographic Information System
Government	Government of Armenia
HDM-4	Highway Development and Management Model (Version – 4)
IFI	International Financial Institution
IT	Information Technology
MCF	Millennium Challenge Fund
MOTC	Ministry of Transport and Communications
NTCC	National Traffic Control Centre
OECD	Organization for Economic Co-operation and Development
PPP	Public Private Partnership
RDCAD	Road Data Collection and Analysis Department
RMS	Road Management System
RMU	Road Maintenance Units
RONET	Road Network Evaluation Tools Model

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Acknowledgments

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Executive Summary

As part of a wider transport sector dialogue with the Government of Armenia (Government), the World Bank conducted a performance review of road maintenance and rehabilitation management in Armenia in order to identify the key financing, policy and institutional drivers for effective and sustainable management of the road network. Based on a thorough diagnostic, this study (Study) developed a set of recommendations aimed at improving the sustainability of road management and financing in order to achieve the overall objective of modernizing the road network.

The Study found that the condition of the majority of the road network remains poor, with the exception of interstate roads. Transport costs are high, and connectivity to markets poor, due to degraded rural infrastructure. Whereas over 80% of interstate roads are in good or fair condition, this is true of only 33% of republican roads, and only 13% of local roads. This reflects under-spending on republican and local roads, as the Government has prioritized expenditures on interstate roads. The current asset value of the entire road network is estimated to be only one-third of what it would have been if there had been proper maintenance in recent years.

The Ministry of Transport and Communication (MTC) is responsible for managing interstate and republican roads. Regional Administrations (Marzes) and local communities are responsible for managing local roads. The MTC has delegated its road management tasks to the Armenian Roads Directorate (ARD). In 2008, the Government launched the Lifeline Road Development Program. The objective of the program was to stimulate economic growth and contribute to poverty reduction by improving a selected network of lifeline roads. The Government defined a lifeline network comprised of about 3,000 km, of which 2,300 km were local roads that were reclassified into republican roads in 2008, and 700 km were already republican roads. As a result, the republican road network increased in length from 1,747 km in 2008 to 4,056 km in 2009.

Since independence in 1991, Armenia has taken steps to improve the management of its road network. For example, all routine maintenance works are contracted out to the private sector under three-year performance-based contracts. The MTC does not benefit fully from these contracts, because they are subject to annual agreements that undermine the benefits of multi-year performance-based contracts.

Road conditions are assessed annually on interstate roads and a sub-set of republican roads. Traffic is measured on only 10 permanent traffic count stations—the ARD is currently in the process of acquiring equipment to measure deflections. The Highway Development and

Management Model (HDM-4),[1] the modern tool for economic evaluation of road works, is used in Armenia at the project and program level, but it is not yet fully utilized at the network level to evaluate the road network for strategic planning and programming of road works.

Institutional Issues

The Study highlights a number of key issues that are adversely affecting the functioning of the road sector in Armenia. These include:

- *Unclear institutional responsibility for maintenance of republican lifeline roads*. A key issue that needs to be resolved is to clearly designate to a single entity the responsibility for properly maintaining republican lifeline roads. The transfer of local roads under the Lifeline Road Development Program discussed above has meant a nearly 70% increase in the road network under the direct responsibility of the MOTC. However, the latter has not received any additional funding from the Ministry of Finance to reflect a much larger road network. As a result, maintenance of these roads was effectively handed back to local administrations (*marzes)*, who also lack sufficient funding for their maintenance;

- *Unjustifiably High design standards used to rehabilitate local roads*. The design standards used to rehabilitate local roads are higher than justified by the level of traffic. Therefore, the limited financial resources are allocated to the rehabilitation of a few segments of roads without improving the overall quality of the network—and this winds up increasing total transport costs. In addition, funding of routine and periodic maintenance is very limited, which results in faster than anticipated deterioration of road assets. This approach ends up being very expensive and unsustainable, because the improved sections will deteriorate before the rest of the network is improved;

- *Problems with the implementation of multi-year performance-based road maintenance contracts (PBCs)*. Routine road maintenance is carried out under PBCs. Although they are multi-year contracts, they are only generic contracts stipulating the extent of the road network and the unit rates for the different maintenance standards and road conditions. Maintenance procurement is carried out through periodic tendering. As a result, each year an annual agreement needs to be signed that defines the exact roads to be maintained and the standards to be achieved, as well as the contract sum for that year. As a consequence,

[1] HDM-4 is a tool developed by the international roads community for the economic evaluation of road projects. It: (i) assesses the current network condition and traffic; (ii) determines maintenance and rehabilitation road works that minimize total transport costs or the costs of sustaining the network in its current condition; (iii) estimates the savings or the costs to the economy to be obtained from maintaining the network at different levels of road condition; (iv) determines the proper allocation of expenditures between recurrent maintenance, periodic maintenance, and rehabilitation road works; and (v) determines the "funding gap," which is defined as the difference between current maintenance spending and required maintenance spending, and the effect of under-spending on increased transport costs.

the whole concept behind multi-year contracts is undermined, because the actual contract sum and required inputs continue to be determined on an annual basis. The Study argues that the annual agreements associated with multi-year contracts should be ended, because they prevent the potential benefits of multi-year contracts from being achieved;

- *Weaknesses in road asset management*. Effective road asset management is dependent on the availability of information and data—this requires the use of a comprehensive computer-based system: a Road Asset Management System (RAMS). The local lifeline roads that have been categorized as republican roads since 2009 (276 roads; around 2,300 km) are not yet included in the road network databank. No proper inventory is available for these roads—an important lacuna.

- *Communication with road-users.* Armenia has made considerable progress in involving the private sector in its effort to deliver an effective road network. However, it needs to adopt procedures used by more mature road organizations in regard to communicating effectively with road-users and the general public. Armenia does not have a well-established system to inform citizens about road conditions. The ARD conducts public consultations with the affected population before starting major road construction or reconstruction projects. However, no surveys have been undertaken by the MOTC or the ARD to assess road-users' satisfaction.

Road Expenditures Financing Gap

The World Bank has estimated an annual financing gap of US$30 million for interstate and republican roads in Armenia. The Study has estimated the amount of spending that would be required to raise the percentage of interstate and republican roads that are in good or fair condition. The Study evaluated four funding options for rehabilitation and maintenance expenditures:

- Option 1: Minimize Total Transport Costs Scenario. This option selects the maintenance standard that minimizes the total transport costs. It assumes that there would be no budget constraints, and that the rehabilitation backlog would be eliminated in five years—with 72% of roads in good or fair condition by 2020.
- Option 2: Expenditures of US$110 Million per Year Scenario. This option takes into consideration maintenance and rehabilitation expenditures on the network in 2009, and assumes expenditures of US$110 per year—with 67% of roads in good or fair condition by 2020.
- Option 3: Eliminate Rehabilitation Backlog in 10 Years Scenario. This is a budget-constrained scenario that eliminates the rehabilitation backlog in 10 years—with 65% of roads in good or fair condition by 2020.

- Option 4: Keep Current Condition Scenario. This option takes into consideration the current condition of the road network and assumes that this condition will be maintained in the future—with 50% of roads in good or fair condition by 2020.

Table 1 presents a summary of the analysis under each of the four scenarios in terms of the required expenditures, and the network condition attained in 2015 and in 2020. It would be impractical for Armenia to implement Option 1 despite its high economic benefits, because it would entail a level of contracting for road works that is beyond the capacity of the ARD. If Armenia were to select the budget-constrained scenario (Option 3), then annual expenditures for interstate and republican roads would be US$98 million for the first five years. This is about 45% higher than the expenditures planned for 2011 (US$68 million). This would raise the issue of how to increase funding for the road sector in order to bridge the US$30 million financing gap.

Table 1. Comparison of Different Expenditure Scenarios

	Roads in Good or Fair Condition in 2015 (%)	Roads in Good or Fair Condition in 2020 (%)	Annual Expenditures for First 5 Years	Annual Expenditures for Next 15 Years	Present Value of Expenditures (20 years)	Financing Gap in First 5 years per year
Option 1	69	72	170	59	920	102
Option 2	62	67	110	73	798	42
Option 3	**55**	**65**	**98**	**74**	**742**	**30**
Option 4	44	50	82	62	658	14

Financing gap in relation to the 2011 planned expenditures (US$68 million)
Source: World Bank staff estimates

Road maintenance expenditures on interstate and republican roads have remained low during the last seven years, while rehabilitation expenditures have increased. The Government spent approximately 0.2% of GDP annually on road maintenance from 2005-2011, an average of US$16 million per year. This contrasts with allocations of about 1% of GDP normally seen in high-income countries with mature networks in order to maintain the road network in good condition. Maintenance allocations for local and republican lifeline roads have been insufficient—and no funds have been allocated for periodic maintenance for interstate and local roads. Community-owned local road networks hardly receive any maintenance allocations, because these networks are funded from local revenue—which is very low.

Key Recommendations

Armenia has greatly modernized the management of its road network in recent years. For example, it has begun to contract all road works and to adopt a form of performance-based maintenance contracts. Nevertheless, there is significant room for reforms aimed at improving

the effectiveness and efficiency of road management in Armenia. Toward that end, the Study makes the following recommendations:

A. **Develop Cost-effective Design Standards for Low-traffic Roads.** This would involve a twofold policy approach to manage the network. For interstate and republican roads, the focus should be on maintaining existing road assets through the proper monitoring, planning and programming of maintenance and rehabilitation works. For lifeline and local roads, the focus should be on providing reliable and cost-effective access for as much of the rural population as possible, rather than on maintaining high standards for a few communities. To properly manage interstate and republican roads requires a clear role, line of accountability and responsibility for the ARD, and a strengthening of the ARD road asset management capacity. The ARD needs to perform a strategic evaluation of the road network and define target performance levels for each road class to be achieved in the future—it also needs to secure the funding required to achieve these targets.

B. **Clarify the Institutional Responsibility for Maintenance of Republican Lifeline Roads.** There is a need to clearly define which institution is responsible for monitoring, management, and maintenance of the lifeline roads. These roads are now classified as republican roads— this has increased the MOTC's road maintenance and rehabilitation funding responsibility.. However, these roads have not yet been fully incorporated into the road inventory and annual budget of the MOTC/ARD. The ARD is a suitable entity to manage these roads, provided it receives proper funding.

C. **Prioritize Periodic Maintenance Road Works.** There is a need to give priority to routine maintenance, periodic maintenance, and rehabilitation road works, because the network has become highly deteriorated. There is a need to give higher priority to periodic maintenance in order to avoid excessive routine maintenance (in particular pothole patching) when periodic maintenance makes more sense.

D. **Finance the US$30 Million Gap for the HDM-4 Scenario 3.** It is recommended that the Government adopt the HDM-4 scenario 3: to eliminate the rehabilitation backlog in 10 years. That would mean a funding gap for the next five years of an estimated US$30 million. The Government should revise its priorities in order to increase the efficiency of maintenance and rehabilitation expenditures. It should redirect funds to projects with high economic priority, introduce improved technology, and adopt comprehensive performance-based contracts. In Armenia, fuel excise taxes and the share of road-user revenues to GDP are lower than in other European countries. Fuel excise taxes could be an attractive instrument option to cover the funding needs for maintenance and rehabilitation works, because they relate to road usage, are easily recognizable, and are simple to administer. Road-user charges should cover operation, maintenance and depreciation of a road, as well as environmental and other social costs. A fuel levy of

US$6 cents per liter would be needed to collect the extra US$30 million in revenues. Priority should be given to rehabilitation and periodic maintenance—which have very high economic returns—rather than to network improvement projects such as new road construction.

E. **Improving efficiency.** The problem of insufficient resources to maintain the existing road network can be addressed by improving the efficiency of resource allocation, improving the prioritization of works, and generating additional revenues. The Study presents six policy measures in this regard:

- *Increase the Efficiency of Current Expenditures.* Road maintenance and network improvements can be more efficiently implemented by determining priorities through the use of a RAMS. This will help: (i) to determine the appropriate level of maintenance activities required and the cost per road link; (ii) to prioritize activities with regard to the available budget and any additional revenues; and (iii) to improve contracting efficiencies. Reducing less productive expenditures and redirecting funds to higher priority projects can help expedite the improvement and maintenance of important roads. Road improvement works—such as widening and upgrading—should be implemented only after passing a rigorous economic evaluation, using tools such as the HDM-4.

- *Develop Cost-effective Design Standards for Low-traffic Roads.* The standards used to rehabilitate local roads are higher than justified by the level of traffic. Thus, the limited financial resources wind up being allocated to the rehabilitation of a few segments of roads, which increases total transport costs without improving the overall quality of the network. The design standards should be reviewed to allow for more cost-effective designs for roads carrying low-traffic volumes. Utilizing thinner asphalt, surface dressings and slurry seals as well as gravel pavements are all options that could be considered to provide good accessibility at a lower cost.

- *Increase Road-user Charges*. Revenue could be increased by introducing additional user charges. The most widespread form of charging users throughout the world is through a surcharge on the consumption of fuel—it relates to road usage, is easily recognizable, and is simple to administer. The financing of roads and highways infrastructure via fuel taxes is the primary pricing policy instrument worldwide. According to a recent report by the GTZ (November 2010), the prices of fuel in Armenia—at 108 US cents per liter for gasoline and 99 US cents for diesel—are lower than the comparable prices in Georgia or Moldova, which have a lower GDP per capita level. This suggests that such fuel price increases in Armenia, if warranted, could still pass affordability considerations.

- *Earmarking.* One option for financing road works is by earmarking, through the creation of a road fund. The Government has plans to earmark additional resources

through legislation requiring fuel taxes (10% on petrol and 10% on diesel) to be used for routine maintenance. The Study found that earmarking funds for routine and periodic maintenance on a pilot basis can provide a good 'test' of its impact assessment demonstrating that the element of entitlement is put to good use.

- *Borrowing*. Borrowing represents the more apparent option for financing gaps in budget allocations. However, borrowing for recurrent expenditures raises the question of whether the return on the expenditure justifies the cost. The World Bank has deemed as appropriate the level of borrowing presented in the Government's planned investment program—in terms of its capacity to service interest and principal repayments. The optimal policy is to borrow for higher return capital works—such as rehabilitation, and to a certain extent periodic maintenance—rather than to borrow for new construction or improvement works.

- *Mobilizing Private Sector Resources through Public-Private Partnerships (PPPs).* Most current forms of PPPs do not appear to be realistic mechanisms for financing roads in Armenia. This reflects: (i) a low traffic volume, which increases the financial burden on either the concessionaire or the Government;[2] (ii) an inadequate legal, technical and financial capacity to prepare and implement PPP projects; (iii) tightened credit conditions and a weak investment climate; (iv) governance concerns; and (v) the absence of access-controlled roads. The Government should consider using PPPs for road maintenance and rehabilitation works through multi-year performance-based contracts for key interstate roads.[3] These types of contracts make it possible for the Government: (i) to transfer the construction risks to the contractor; and (ii) to ensure optimum management of a section of a road or road network over a long period—up to 10 years.

F. **Review existing PBCs and expand the scope of new PBCs.** There is a need to explore expanding the use of performance-based contracts to cover periodic maintenance and rehabilitation works in addition to routine maintenance. The preferred contract option is multi-year PBCs that assign the responsibility to a contractor to maintain a network of roads at a defined level of service. The reasons are as follows: (i) because it secures the funding requirements for maintenance during the duration of the contract; (ii) because it avoids cost overruns; and (iii) because it yields better overall quality road works and road-user satisfaction. On the current performance-based routine maintenance contracts, annual agreements should be abolished, and procurement carried out in a staggered manner.

[2] If the concessionaire was willing to assume traffic risk, low traffic volumes would mean lower revenues and potential difficulties in meeting debt service requirements. If the Government were to bear the traffic risk by agreeing to an availability payment, it would lose some of the toll revenue it had budgeted.

[3] Armenia: Private Participation in the Road Sector, World Bank Guidance Note prepared by Jukka-Pekka Strand and Vickram Cuttaree, March 2011, Washington D.C.: World Bank.

G. **Strengthen the Road Asset Management System.** There is a need to better institutionalize a RAMS within the ARS. This requires: (i) improving the processes of data collection and evaluation; (ii) ensuring that the dedicated group in charge of the system has clear obligations, proper resources, and appropriate technical capacity; and (iii) procuring and maintaining proper equipment. The weakest elements of the current system are: (i) the lack of a mapping interface; (ii) the limited network data collection for republican roads; and (iii) the limited network traffic counts program. Incorporating lifeline roads into the RAMS should be a high priority for the ARD. The local lifeline roads that have been categorized as republican roads since 2009 (276 roads; around 2,300 km) have not yet been included in the road network database. No proper inventory is available for these roads—an important lacuna.

Table 2 presents key priority recommendations for each road class that would make a high short-term impact on the sustainability of road management in Armenia.

Table 2. High Priority Recommendations

Road Class	Main Focus	Key Recommendations
Interstate and Republican Roads	Maintain the existing road assets by the proper monitoring, planning and programming of maintenance works	a) Proper allocation of funds for maintenance and rehabilitation works b) Move towards multi-year performance-based road maintenance contracts c) Establish a sustainable road asset management system
Republican Lifeline Roads	Define core road network and ensure sustainable maintenance funds	a) Define institutional responsibility for maintenance of republican lifeline roads
Local Roads	Promote reliable and cost-effective access to as much of the rural population as possible, rather than high standards for a few	a) Develop cost-effective design standards for low-traffic roads.

A. Introduction

1. A well-maintained road network that provides the level of service required by road-users is an important element of Armenia's development strategy to accelerate economic growth and reduce poverty. As part of this strategy, the Government of Armenia (Government) has undertaken strategic reforms and major capital improvements and rehabilitation on the interstate road network. However, the secondary and local roads continue to be underfunded, and a large maintenance backlog has been accumulating in recent years. Deferred maintenance leads to a future burden of more expensive rehabilitation and road reconstruction: for every US$1 in deferred maintenance, there is an associated US$4 cost to road-users.[4] To avoid such a scenario, the Government needs: (i) to devise an institutional and financing framework that provides adequate funding for maintenance and rehabilitation; and (ii) to finance capital improvements on key priority roads.

2. The objectives of this study (Study) are: (i) to identify the weaknesses and challenges confronting the sustainability of road maintenance and rehabilitation management; (ii) to determine to what extent these factors are linked to particular institutional and financing arrangements; and (iii) to assess how these factors can be resolved. The Study makes a series of recommendations aimed at improving the sustainability of the management and financing of the road sector.

3. First, the Study provides an overview of the road sector and the condition of the road network. Then it turns to a review of road management and financing in Armenia. The Study reviews the current institutional and technical arrangements, with regard to the ability to effectively plan, design, construct, and maintain the road network. It gives particular emphasis to the implementation arrangements for the road sector, including: (i) budgeting; (ii) management and resources; (iii) technical standards in use; (iv) quality assurance and education/training; and (v) provision of maintenance for different road classes. It then assesses actual expenditures for the maintenance and rehabilitation of international, secondary, and local roads using the Highway Development and Management Model (HDM-4)[5], before exploring different options

[4] Road user costs refer to fuel, lubricants, tire, crew, maintenance parts and labor, depreciation, interest, overheads, and passenger and cargo time costs. This scenario can be found in the World Bank Policy Paper "Road Deterioration in Developing Countries – Causes and Remedies", published in 1988. According to the paper, road conditions in 85 developing countries have a maintenance backlog of an estimated US$40-45 billion, which could have been avoided had timely maintenance costing less than US$12 billion been carried out.

[5] HDM-4 is a tool developed by the international roads community for the economic evaluation of road projects. It: (i) assesses the current network condition and traffic; (ii) determines maintenance and rehabilitation road works that minimize total transport costs or the costs of sustaining the network in its current condition; (iii) estimates the savings or the costs to the economy to be obtained from maintaining the network at different levels of road condition; (iv) determines the proper allocation of expenditures between recurrent maintenance, periodic maintenance, and rehabilitation road works; and (v) determines the "funding gap", which is defined as the difference

for financing road maintenance in a sustainable manner. It concludes with a series of recommendations. The key principles underlying the review are the following:

a) **Sustainable road maintenance financing**, to ensure that road maintenance and rehabilitation funds are sufficient to keep the network operating at an acceptable level of service;
b) **Efficient allocation of resources**, to ensure that resources are distributed among different uses so as to maximize their contribution to the objectives and results of government programs; and
c) **Value-for-money**, to ensure that the results are achieved at the least possible resource cost.

4. The Study was informed: (i) by data collected in Armenia; (ii) by a review of the existing work in the sector—particularly the various technical assistance activities undertaken by different International Financial Institution (IFI) financed projects; and (iii) by interviews with government officials and other sector stakeholders in Armenia. The findings of the Study are timely. It is hoped that they will inform a policy discussion on the need to raise expenditures on the maintenance of the road network, and provide a roadmap for financing these needs in an efficient, cost-effective manner.

B. Overview of the Armenian Road Sector

5. **The location, topography and geopolitics of Armenia present a particular transport challenge.** Armenia is a landlocked country located in the strategically important Southern Caucasus. It shares a border with four countries: Georgia, Azerbaijan, Turkey, and Iran. Only two of those borders are open: the northern border with Georgia, and the southern border with Iran. As a result of the Nagorno-Karabakh conflict, the western border with Turkey was closed in 1993 and the eastern border with Azerbaijan was closed in 1991. Armenia has an average elevation of 1,800 meters and a severe continental climate: very low winter temperatures, heavy snowfall, and high intensity rainfall are experienced throughout the country, including in key transport routes. The combination of all of these factors results in high transport costs and expensive infrastructure maintenance and development.

6. **Armenia is highly urbanized, with 64% of the population living in urban areas.** The country has a population of 3.2 million. However, a large number of Armenians live or work abroad for most of the year. The average resident population is believed to be under 3 million, one-third of which live in Yerevan, the capital city. A high priority must be given to urban

between current maintenance spending and required maintenance spending, and the effect of under-spending on increased transport costs.

transport, and to connectivity to and from Yerevan—but the widening income gap with the rest of the country may be exacerbated if limited resources are overly focused on the capital.[6]

7. **The Ministry of Transport and Communications (MOTC) is responsible for the road sector in Armenia**.[7] As per Government Decree No. 112 of 2008, the MOTC is responsible for formulating transport programs, projects, and regulatory measures, and for planning transport systems. It is also responsible for managing interstate and republican roads. Regional administrations (*marzes*) are responsible for managing local roads. The Armenian Road Directorate (ARD) is the agency responsible for maintaining interstate and republican roads: the MOTC delegates road-related tasks to the ARD through formal annual contracts. The procurement law defines the State Procurement Agency as the sole procurement body. Thus, the latter, on behalf of the MOTC, carries out procurement matters.

Road Network

8. **The total length of the road network is 7,704 km, excluding urban roads**.[8] Roads are classified into one of four different categories based on the road's functions and administration: (i) interstate; (ii) republican; (iii) local; and (iv) urban. Most of the road network in Armenia was built in the 1960s and 1970s—it was mostly funded by Diaspora (largely based in the Russian Federation and the USA). Since the early 1990s, IFIs—such as the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the Millennium Challenge Corporation (MCC), and the World Bank—have been the primary source of financing for the Armenian road sector. Interstate roads have been largely rehabilitated in the past decade through grants and IFI support. The percentage of paved roads, at 93%, is high compared to other developing countries, and in line with most European countries. Although the country lacks a bypass for Yerevan, the present road network and capacity appear to be sufficient. Figure 1 presents the network density of different European countries—both within the EU and outside—measured in terms of road length per square kilometers of land area and per 1,000 persons. The road network density of Armenia is about 2.6 km per thousand persons and 279 km per thousand square km, which falls short of OECD levels—this reflects in part the difficulties facing the road sector to provide basic access to the rural population.

[6] Armenia: Transport Sector Development Strategy, November 2008, financed by the ADB Technical Assistance Special Fund.

[7] The road sector is regulated by: (i) the law on Automobile Roads dated 5.12.2006, in force from 2007; (ii) the law on Procurement dated 6.12.2004, in force from 1.1.2005; (iii) the Government Decree dated 9.12.2004. N 1942, the "Methodological Order"; and (iv) the Government Decree dated 10.01.2008. N 112, the "Definition of State Managerial Body and Titling of the General Purpose State Automobile Roads."

[8] This report focuses on interstate, republican and local roads.

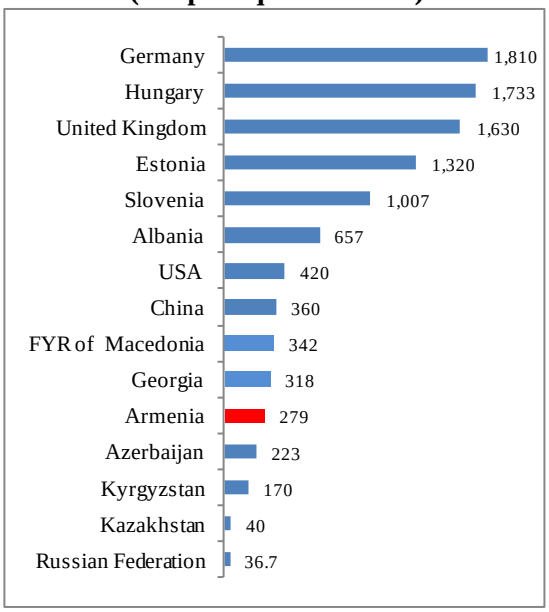
Table 3. Road Definition and Length, 2009

Road Class	Definition of Road Class	Length (km)	Paved Roads (%)
Interstate roads	Connects to other countries' road networks and provides international access	1,686	100
Republican roads	Connects districts and cultural centers	4,056	89
Local roads	Connects villages to the republican network	1,962	84
Urban roads	Roads located in urban areas	3,114	100
Total		10,818	93

Sources: Government of Armenia, Statistical Yearbook of Armenia 2009; ARD.

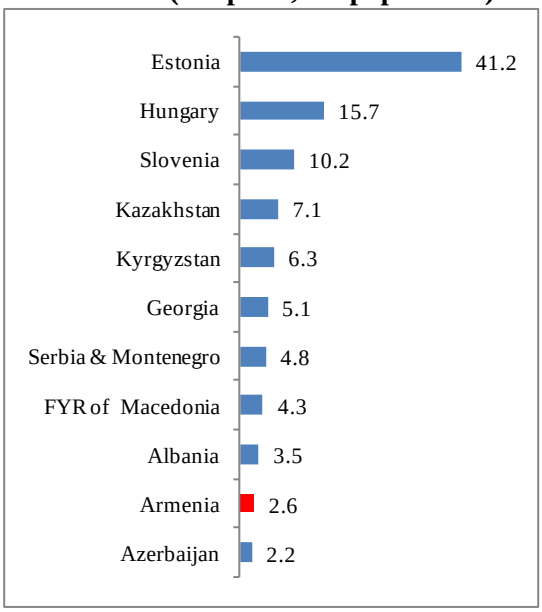
Figure 1. Road Density

(km per sq km. of land)



Source: World Bank

(km per 1,000 population)



Source: Word Bank.

9. **In 2008, the Government launched the Lifeline Road Development Program.** The objective of the program was to stimulate economic growth and contribute to poverty reduction by improving a selected network of lifeline roads. The Government defined a lifeline network comprised of about 3,000 km, of which 2,300 km were local roads that were reclassified into republican roads in 2008, and 700 km were already republican roads. Lifeline roads are mainly rural roads that connect rural communities to an interstate road. As a result of the program, the republican road network more than doubled in length between 2008 and 2009. Although the lifeline roads were placed under the direct responsibility of the MOTC, in practice, the marzes remain responsible for their management. Likewise, where local lifeline roads pass through communities, it is the marzes that are responsible for their maintenance. Republican roads are normally the responsibility of the ARD, but—following the reclassification of roads—there is an unclear delineation of responsibility with regard to the management and maintenance of lifeline roads. This, in turn, compromises the financial sustainability of republican road maintenance.

Table 4. Trend of Road Classes Lengths in km

	2004	2005	2006	2007	2008	2009
Interstate	1,561	1,561	1,561	1,561	1,686	1,686
Republican	1,832	1,832	1,832	1,832	1,747	4,056
Local	4,236	4,122	4,111	4,122	4,271	1,962
Total	**7,629**	**7,515**	**7,504**	**7,515**	**7,704**	**7,704**

Sources: Government of Armenia, Statistical Yearbook of Armenia 2009; ARD.

10. **Less than half of the road network in Armenia is in good or fair condition.** The majority of republican and local roads have deteriorated since independence—there has been almost no maintenance for years. Most of the interstate road network has been rehabilitated at some point since it was created, but there are some interstate roads that are still waiting for rehabilitation and there are others that are waiting for the periodic maintenance they require. In short, there is no long-term maintenance strategy for the interstate network. Only about 39% of the total road network and 49% of the main roads (interstate and republican) are in good or fair condition. This is well below an international benchmark: usually 70% of main roads are in good to fair condition in developing countries. Table 5 indicates that a strong majority of interstate roads are in fair condition and in need of only periodic maintenance (81%). By contrast, a strong majority of republican roads are in poor or very poor condition and in need of rehabilitation (67%). There is limited reliable information regarding the condition of local roads, but engineering estimates suggest that about 87% of local roads are in poor or very poor condition. Overall, given the road network condition, operating costs to road-users remain high.

Table 5. Length and Condition of the National Road Network, 2009

Condition	Interstate Roads		Republican Roads		Local Roads		Total	
	km	%	km	%	Km	%	Km	%
Good	54	3.2%	690	17.0%	259	13.2%	1,002	13.0%
Fair	1,371	81.3%	649	16.0%	0	0.0%	2,020	26.2%
Poor	221	13.1%	1,095	27.0%	383	19.5%	1,699	22.1%
Very Poor	39	2.3%	1,622	40.0%	1,321	67.3%	2,982	38.7%
Total	**1,686**	**100%**	**4,056**	**100%**	**1,962**	**100%**	**7,704**	**100%**

Source: ARD Road Databank.

11. The current asset value of the road network is estimated at 76% of what it would be if there had been proper maintenance and rehabilitation works. The current asset value of interstate and republican roads is estimated at US$2,903 million—equal to 33% of GDP. This is significantly less than the maximum possible asset value of US$3,810 million—computed under

the assumption that all roads are in good condition.[9] As a result of insufficient maintenance, there is a 16% decrease in the asset value of interstate roads, a 27% decrease in republican main roads, and a 35% decrease in republican lifeline roads. This suggests the need to prioritize scarce funding to maintain and rehabilitate lifeline roads. Table 6 presents the key characteristics of the main roads in Armenia, showing that interstate roads carry most of the traffic despite representing only 31% of the network, excluding urban roads (Figure 3).

Table 6. Road Network Condition and Asset Value

Network	Length (km)	Utilization (M veh-km/year)	Good/Fair Roads (%)	Max Asset Value (US$ Mil)	Current Asset Value (US$ Mil)	Current Value per GDP (%)	Average Traffic (AADT)
Interstate	1,686	2,571	85%	1,846	1,548	17.8%	3,816
Republican Main	1,697	629	51%	1,066	774	8.9%	899
Republican Lifeline	2,359	572	17%	898	582	6.7%	732
Total	**5,742**	3,772	**49%**	**3,810**	**2,903**	**33.3%**	**1,751**

Source: HDM-4 Evaluation

Figure 2. Main Roads Asset Value

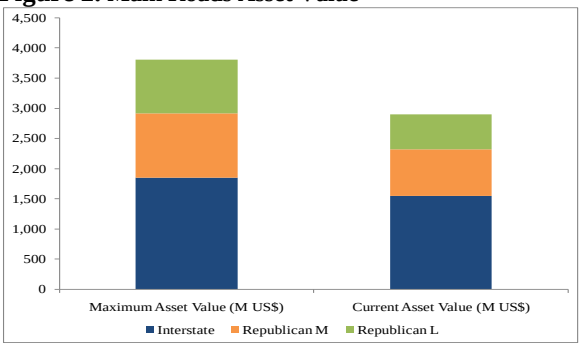
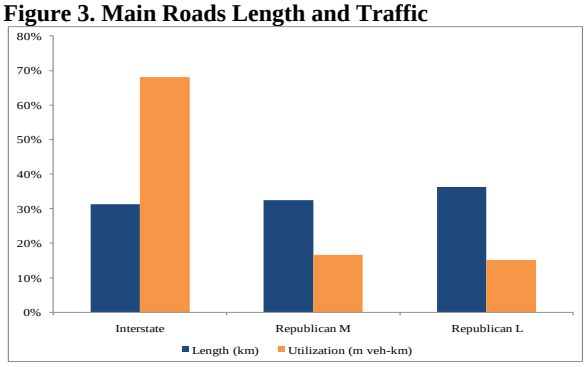


Figure 3. Main Roads Length and Traffic



Source: HDM-4 Evaluation

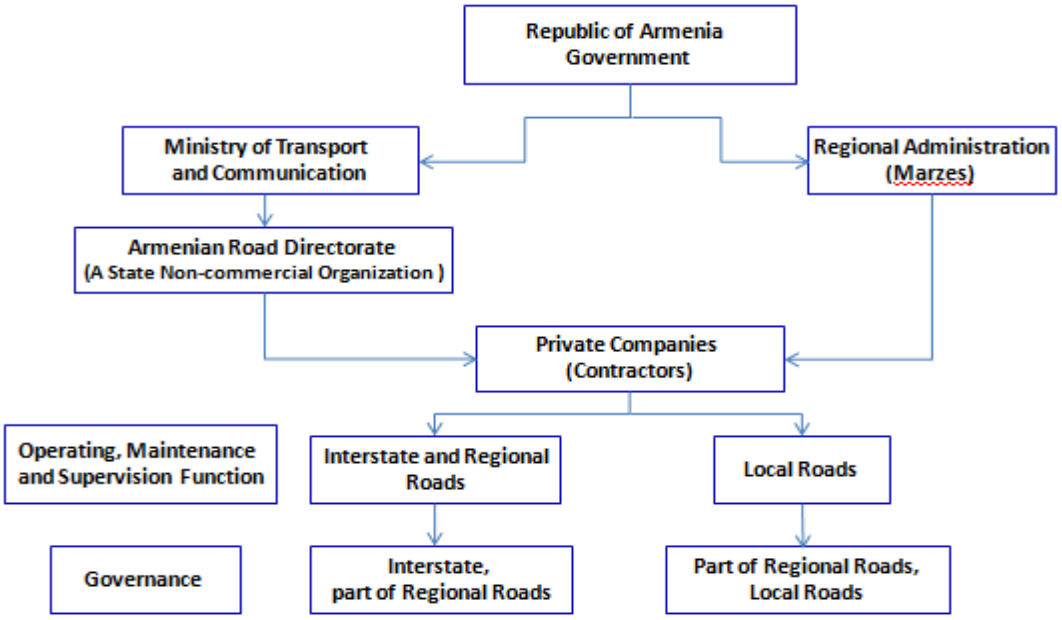
Institutional Setup

12. **Road management structure.** In general, the road management structure currently in place appears adequate for the management of interstate and republican roads. While countries may adopt different institutional arrangements to manage roads, the following trends are common to those countries seeking increased efficiency and effectiveness in providing the public with an adequate road infrastructure:

[9] Current asset value computed with HDM-4 accounting for the reduction of the network maximum asset value, which is the asset value considering all roads in good condition, function of the replacement value needed to bring fair and poor condition roads to good condition.

a) Increased involvement of the private sector in building, maintaining, managing, operating, and financing road infrastructure; and
b) More emphasis placed on the needs of road-users, and the development of methods to communicate with road-users to take into account their needs and concerns in the provision of road infrastructure.

Figure 4. Organizational Structure of the Road Sector in Armenia



Source: ARD

13. **The Armenian Road Directorate (ARD) is a public non-commercial organization responsible for managing interstate and republican roads.** The ARD does not have a formal mission statement, but its annual contracts with the MOTC clearly define its objectives. These are: (i) to support Armenian road network development, maintenance and development of State strategic plan implementation; (ii) to support international organizations and donor countries in the development, use and maintenance of the road network; (iii) to conduct laboratory and design research, surveys and analyses; (iv) to analyze traffic accidents and recommend actions to reduce their incidence; and (v) to make periodic observations of roads and engineering constructions. Figure 4 presents the organizational structure of the road sector in Armenia.

14. **ARD staffing**. The ARD is a relatively streamlined road agency, with a staff that has a good skill mix. By the end of 2010, it plans to have established 10 regional road maintenance groups, with a total of 15 engineers. This will increase overall staff from 66 to 81. These road maintenance groups will work as project managers for maintenance, and they will monitor road conditions—they will work under the Maintenance Department. ARD salaries are higher than

those for the public service and competitive with those of the private sector. The ARD is responsible for about 3,500 km of roads (without including lifeline roads) Thus, it has a ratio of about 2.3 staff/100 km.[10]

15. **ARD staff training.** The education and training system of the ARD is generally considered satisfactory. However, there are several areas where more training should be conducted. These include: (i) the use and interpretation of road measuring equipment, such as falling weight deflectometers (FWD); (ii) road materials; (iii) economic evaluation of road investments; (iv) contract management; (v) road management planning; and (vi) international road standards.

16. **Communication with road-users.** Armenia has made considerable progress in involving the private sector in its effort to deliver an effective road network. However, it is far behind more mature road organizations in regard to communicating effectively with road-users and the general public. Armenia does not have a well-established system to inform citizens about road conditions. For example, in the winter, it is difficult for users to find out whether or not a road is open to traffic. The ARD could benefit from the experience of more developed road agencies. The UK Highways Agency, which is called Traffic England, is an example of a good communication system—it provides road-users with an up-to-date look at the traffic situation on England's motorways and major roads.[11] The service is run by the National Traffic Control Centre (NTCC) of the Highways Agency.[12] The UK example may be too sophisticated for immediate implementation in Armenia, but a simplified information system could be implemented in a relatively short period, which would be of considerable help to road-users.

17. The ARD conducts public consultations with the affected population before starting major road construction or reconstruction projects. Thus, the affected population can make suggestions that the ARD can take into consideration before finalizing the engineering design or implementing the works. Nevertheless, public hearings have been limited to IFI-financed projects, because the approach has yet to be internalized by the ARD and the MOTC.

18. **Road-user satisfaction.** No surveys have been undertaken by the MOTC or the ARD to assess road-users' satisfaction. A number of more mature road organizations, such as the U.K. Highways Agency[13] and the Swedish Road Administration,[14] use performance management systems to demonstrate accountability to elected officials and to the public—including the periodic carrying out of road-user satisfaction surveys. More specifically, performance management can be used by road agencies: (i) to establish goals and performance targets for

[10] By comparison, the ratio is about 1.5 staff/100 km for Latvia; 0.7 staff/100 km for Lithuania; and 10.0 staff/100 km for Slovakia.
[11] Traffic England home page: http://www.trafficengland.co.uk/index.aspx
[12] NTCC: http://www.highways.gov.uk/knowledge/12825.aspx
[13] UK Highways Agency Business Plan 2009-2010.
[14] As summarized in "Linking Transportation Performance and Accountability." U.S. Federal Highway Administration. 2010. Washington, D.C. USA. http://www.international.fhwa.dot.gov/pubs/pl10009/pl10009.pdf

managing, explaining, delivering, and adjusting their roads budgets and internal activities; (ii) to establish effective and achievable performance levels based on input from the public, elected officials, and the business community; and (iii) to demonstrate good governance and accountability in meeting or exceeding performance expectations.[15] [16]

19. **With the rehabilitation of republican lifeline roads, proper maintenance of these roads is becoming a priority**. Maintenance is critical to ensure that rehabilitated roads remain in good condition over an extended period, and that the expected benefits from the investment are realized. However, maintenance of these roads is problematic, because a number of different actors share responsibility. The ten *marzes* are responsible for the maintenance of State-owned local roads. However, lifeline local roads have been officially reclassified as republican roads—thus, the MOTC via the ARD is now responsible for their maintenance. The transfer of local lifeline roads has meant a nearly 70% increase in the amount of road network under the direct responsibility of the MOTC—nevertheless, it has received no additional funding from the Ministry of Finance toward this end. As a result, maintenance of these roads has been effectively handed back to the *marzes*, who lack sufficient funding for their maintenance. This has led to a difficult situation in which policy and practice are not in line and it is unclear where capacities and resources need to be increased in order to improve maintenance of local roads. The communities are responsible for the maintenance of lifeline roads that pass through their community areas. The State—including both the MOTC and the *marzes*—is not allowed to intervene in community-owned roads. Most communities are not able to provide adequate maintenance, which leads to accelerated deterioration.

20. Policymakers need to unequivocally designate responsibility for maintaining lifeline roads to a single entity. This responsibility could be assigned to any of the following: (i) the ARD, which manages interstate and republican roads; (ii) the *marzes*, because most of these local roads play an important regional role within the *marze*; or (iii) another existing central agency working in conjunction with the *marzes*, if the *marzes* lack the technical capacity, proper coordination and funding for the maintenance of these roads. This central entity could channel resources for lifeline road maintenance and coordinate with the *marzes* the planning and execution of road works. Transferring these roads to the MOTC and the ARD would place a financial burden on these entities—thus, proper funding would need to be secured for the

[15] World Bank Transport Paper No. 32, "A Review of Institutional Arrangements for Road Asset Management: Lessons for the Developing World." Cesar Queiroz and Henry Kerali. Washington, D.C. USA. http://go.worldbank.org/9XN7FBUCD0

[16] Examples of key performance measures used by the U.K. Highways Agency include: (i) Road Safety: By 2010 reduce by a third (i.e., to 2,244) the number of people killed or seriously injured on the core network compared with the 1994-98 average of 3,366; (ii) Road Maintenance: Maintain the strategic road network in a safe and reliable condition, and deliver value for money, with the following targets: (a) maintain a road surface condition index of 100 ±1 within the renewal of roads budget; and (b) deliver selected maintenance renewals costs at an average level below inflation by the end of 2010-11 when compared with 2009-10; (iii) Customer Satisfaction: (a) Improve road user satisfaction by at least 0.2 percentage points compared with the level achieved in 2009-10; and (b) Develop and agree a new customer satisfaction measure and target to be implemented for 2011-12. See UK Highways Agency Business Plan 2010-2011, Annex A: http://www.highways.gov.uk/documents/Business_Plan_10-11_Web.pdf

maintenance of these roads. Policymakers also need to explicitly assign responsibility for the maintenance of the community-owned sections of these local roads, although this would not necessarily involve a change of ownership. Before the other recommendations laid out in this document can be effectively implemented, a clear designation of responsibility for the maintenance of lifeline roads must first be established.

21. Armenia has about 960 km of State-owned local roads and 1,000 km of community-owned local roads. These roads carry limited traffic and serve local communities. For these reasons, the Study recommends that they should remain under the responsibility of *marzes*.

22. Lifeline and local roads serve an economic and social function by providing access for the rural population to markets and social services. For this reason, the Study recommends a policy approach that places an emphasis on providing reliable and cost-effective access to as much of the rural population as possible, rather than maintaining high standards for a few. There is a need to quantify the population served by each road and determine its relative importance in regard to access to markets and social services, with the objective of maximizing the population served per investment.

23. **Road Safety.** A National Road Safety Council has been established under the Prime Minister's office that has as its objective to decrease the number of road crash fatalities in the country by 30% within the next five years. The ARD currently provides no assistance to drivers in the event of incidents/accidents. Both the MOTC and the ARD recognize that there is a need to improve road safety in Armenia, through: (i) regulations and road rules; (ii) driver education (many drivers do not follow basic road safety rules); (iii) vehicle inspection (vehicles are often in poor condition, thus posing a traffic hazard); and (iv) implementation of road safety audits in a more systematic way. The existing legislation does not address the transportation of hazardous materials and abnormal cargo sizes. Poor road infrastructure—including narrow and winding sections, and poor road signs and marking—also contribute to the high accident rates in the country.

Road Maintenance

24. **Road maintenance contracts.** The ARD has 20 staff dedicated to planning and supervising road maintenance: five in the headquarters, and 15 in the regions. The ARD staff periodically inspects roads under performance-based routine maintenance contracts. In general, the ARD has been satisfied with the quality of maintenance under such contracts.[17] Despite the existence of these routine maintenance contracts, roads are not in good condition. This is due to a lack of periodic maintenance, and insufficient funding for maintenance and rehabilitation. The latest road roughness survey—carried out in 2008 on a sampling basis—showed an average international roughness index (IRI) of 4.9 m/km for interstate roads, and 8.6 m/km for republican

[17] The contractors are required to place on the road side signs with their names and telephone numbers, to facilitate road users' complaints in case of poor road condition.

roads.[18] In general, asphalt mix roads with an IRI range of 3.5 m/km to 5.5 m/km are considered to be in fair condition; and from an IRI of 5.5 m/km to 10.5 m/km, in poor condition.[19]

25. **Routine road maintenance is carried out under performance-based contracts.**[20] This means that maintenance payments are not made on the basis of the amount of work carried out, but rather on the basis of the condition of the road and the amount of inputs used (input-based). The payments are fixed-unit rates per km of road—depending on the administrative level of the road, its condition and the selected maintenance standard—whereby differentiation is made between summer and winter maintenance. The performance-based maintenance system in Armenia is defined by a Methodological Order that was created by government decree in 2004, and is currently being revised. Routine maintenance consists of winter maintenance and summer maintenance, which affects the pavement performance of the roads. The first contracts were tendered in 2004 and they extend for a period of three years. The draft new Order is extending this contract period to five years. The idea behind multi-year contracts is that the procurement process will need to be repeated less often, and, more importantly, that contractors will have greater income security, which will motivate them to invest in better equipment and to purchase required materials in bulk—thereby reducing their costs, which will in turn reduce the unit rates they submit.

26. **Multi-year contracts require signature of annual agreements.** Although the contracts are multi-year, they are only generic contracts stipulating the extent of the road network and the unit rates for the different maintenance standards and road conditions. Maintenance procurement is carried out through periodic tendering. As a result, each year an annual agreement needs to be signed that defines the exact roads to be maintained and the standards to be achieved, as well as the contract sum for that year. The total annual contract sum may change depending on the budget allocated to the *marzes*, the condition of the roads to be maintained, and the type of activities to be carried out—these may vary significantly between one year and the next. As a consequence, the whole concept behind multi-year contracts is undermined, because the actual contract sum and required inputs continue to be determined on an annual basis. The use of annual agreements has serious implications regarding road condition and maintenance standards**.** Multi-year contracts imply that road conditions would be assessed only at the beginning of the contract after which the contractor is responsible for ensuring a certain maintenance standard for the entire contract period. However, this is not occurring in Armenia, because in practice maintenance procurement is being carried out through annual tendering.

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[18] ADB Technical Assistance Consultant's Report, "Armenia: Preparing the North-South Road Corridor Development Project," Project Number: 7208-ARM, May 2010, page 22.
http://www.adb.org/Documents/Reports/Consultant/ARM/42145/42145-01-arm-tacr.pdf

[19] See RONET's default values in SSATP Working Paper No. 89-A, "Road Network Evaluation Tools (RONET)," Version 2.0, User's Guide, Rodrigo Archondo-Callao, January 2009, page 11. Available at:
http://go.worldbank.org/FF0CT8M770

[20] See Annex 2 for a discussion on performance based maintenance contracts.

27. The practice of requiring annual agreements should be ended, because it prevents the potential benefits of multi-year contracts from being achieved. Furthermore, because contracts are procured at the same time instead of in a staggered manner, the burden on the procurement department is high. The Study recommends that for the benefits of multi-year contracts to be achieved, the annual agreements should be abolished and the ARD should consider the feasibility for the procurement to be carried out in a staggered manner. In addition, there are too many small contracts (38 contracts for 34 contractors) for the size of the network—and a large amount of funds are spent on winter maintenance—in some areas the entire budget. It creates a problem for any performance-based approach when the bulk of the funds are spent on these kind of 'emergency' items.

28. **All performance-based contracts (PBCs) are awarded through competitive biddings carried out by the State Procurement Agency**. This is also the case for all locally-financed contracts for local roads, where road maintenance contracts are managed by the *marzes'* administrations. The ARD is responsible for supervising the contractual obligations of private contractors and consultants. Road maintenance is executed by private contractors (with the exception of one public enterprise), that normally hire local villagers living nearby for routine and some winter maintenance activities. The ARD is currently preparing bidding documents (with revised methodology) for a second phase of PBCs to be awarded for the 2011-2015 period.

29. **Limited funds are allocated for periodic road maintenance**. Periodic maintenance is undertaken every three to five years, and is concerned with rectifying defects that are outside the scope of routine maintenance. The near total absence of periodic maintenance ends up being a very expensive—and unsustainable—approach, because rehabilitated road sections rapidly deteriorate before the rest of the network is improved. Thus far, there has been limited preventive periodic maintenance, such as the application of slurry seals or fog seals. Maintenance funds are allocated and used primarily for winter and routine maintenance. Since 2005, routine maintenance work has been contracted out under three-year PBCs. During a first phase of contract maintenance from 2007-2010, a total of 38 PBCs were awarded to 34 contractors. This covered a road network of 3,393 km, including 1,561 km of Interstate roads and 1,832 km of republican roads. Routine maintenance is not performed for roads that are rehabilitated, particularly during the defects liability period.

30. **The ARD should consider replacing the current system with multi-year performance-based maintenance and rehabilitation contracts.**[21] This approach would offer several advantages. These include: (i) cost savings in managing and maintaining road assets; (ii) greater expenditure certainty for road agencies; (iii) ability to manage the road network with fewer agency staff; (iv) better customer satisfaction; and (v) stable multi-year financing of maintenance and rehabilitation. These contracts could lead to cost savings through: (i) incentives

[21] See Annexes 3 and 4 for details on a comparison between traditional contracting and output and performance road contracts (OPRC) in the road sector, and recent experience with OPRC involved rehabilitation and maintenance.

to the private sector for innovation and higher productivity; (ii) reduction in administrative expenses and road agency overheads—due to better packaging of contracts, which would decrease the number of agency personnel required to administer and supervise contracts; and (iii) significantly greater flexibility (in the private sector as opposed to the public sector) in regard to rewarding performance and reacting quickly to non-performers. This approach is more appropriate for major arterial roads—interstate roads—that should be given higher priority for sustainable funding for maintenance.

31. **The standards used to rehabilitate local roads are higher than justified by the level of traffic.** Therefore, the limited financial resources are allocated to the rehabilitation of a few segments of roads without improving the overall quality of the network—and this winds up increasing total transport costs. For example, rehabilitating a low-volume road with an overlay of 80mm instead of 50mm, not only increases the rehabilitation costs by around 40% but also increases the present value of total transport costs (road agency plus road-user costs) over a 20-year evaluation period by 2%; thus, overdesign standards penalize road-users in the long-run. The design standard should be reviewed with an aim toward creating more cost-effective designs for roads carrying lower traffic volume. For example, thinner asphalt, surface dressings and slurry seals, and gravel pavements are all options that could be considered to provide good accessibility at a lower cost. In addition, funding of routine and periodic maintenance is very limited, which results in faster than anticipated deterioration of road assets. This approach ends up being very expensive and unsustainable, because the improved sections will deteriorate before the rest of the network is improved.

32. **One option is to focus on maintaining the quality of the road network at an appropriate level within specific geographical areas relevant to the agricultural sector**. This could be implemented through performance-based contracts that would require the contractor to be responsible for undertaking all road improvements, as well as routine and periodic maintenance, in order to keep the assigned road network at the specified level of service for a given number of years. This approach would maximize the benefit to the agriculture sector and other road-users, because a larger portion of the road network would be kept at the appropriate level of service. Moreover, it would be a more efficient use of financial resources for the Government, because the contract would be designed so as to minimize the long-term cost of managing the local road network. Finally, local contractors should be enabled to participate strongly in these performance-based contracts, and thereby encouraged to invest in more efficient equipment and to improve their technical expertise.

Road Asset Management System

33. **The first effort in Armenia to implement a modern road asset management system (RAMS) started in 2005** when the ARD created the Road Data Collection and Analysis Department (RDCAD) to manage the road network data and evaluate it at project and network levels. The RDCAD is composed of seven professionals who are in charge of: (i) road condition

data collection; (ii) road traffic data collection; (iii) road safety data collection; (iv) management of the road network databank; (v) the production of thematic graphs; and (vi) overall support to the ARD on road network technical issues. In 2005, the RDCAD developed a road network databank that is capable of managing network data and creating the Highway Development and Management model[22] (HDM-4) road network files for homogeneous road sections. The findings are presented in an annual report. Two ARD professionals have some knowledge of the HDM-4 model, but have not received adequate formal training on how to use it.

34. **Incorporating lifeline roads in the RADS should be a high priority for the ARD.** An inventory of 17 interstate roads (around 1,700 km) and 56 republican Roads (around 1,700 km) has been carried out by the RDCAD since 2005—it is included in the road network databank. The local lifeline roads that have been categorized as republican roads since 2009 (276 roads; around 2,300 km) are not yet included in the road network databank. No proper inventory is available for these roads—an important lacuna. The RDCAD uses a ROASMASTER to measure road surface distress and roughness on an annual basis. This work is done over the entire interstate road network and about one-third of the length of the republican roads—but no roughness measures are done on the lifeline roads. The RDCAD also measures traffic on 10 permanent traffic count stations located on interstate roads. Currently, the ARD is in the process of purchasing a Falling Weight Deflectometer (FWD). The RDCAD will require additional resources to extend the scope of the network data collection—it will implement a Geographical Information System (GIS) that will require around four new staff.

35. **Recommendations for establishing a sustainable road management system in Armenia**. In order to establish a sustainable network data collection and evaluation with clear objectives, resources and technical capacity, the Study recommends a policy approach for interstate and republican roads that focuses on maintaining existing road assets through the proper monitoring, planning and programming of maintenance and rehabilitation works. To this end, a number of actions are required:

36. *Comprehensiveness of road network database*. Ensure that the road network databank and the GIS to be procured are fully operational with an efficient interface and a useful reporting system and are able to manage all road network data collected in the future. Among other things, this requires collecting inventory information for all republican roads, including the lifeline roads—and, if possible, all other local roads. The inventory of interstate roads should be updated as necessary. To succeed, this will require coordination between all of the departments of the ARD in defining the information generated by the systems. Monitoring the network condition

[22] The HDM-4 model is a modern tool for the economic evaluation of road works and the provision of support for the planning and programming of road works. It was developed from extensive research in developing countries regarding road deterioration and road-user effect. It compares project alternatives in terms of road agency costs, road-user costs and total transport costs.
http://www.hdmglobal.com/

and traffic, and assessing alternative policy options, are essential for high-quality decision-making to maximize the economic and social benefits;

37. *Methodology for evaluating road network data.* Ensure that a proper methodology exists to evaluate the network data for monitoring, strategic planning, programming and economic evaluation of road works. For this purpose, the HDM-4 model or a similar model could be used that performs a life-cycle economic evaluation of project-alternatives. This would require that the RAMS generates road network data files that are suitable for use by HDM-4 for project and network level analyses, and that the ARD staff are properly trained on the use of the model;

38. *Evaluation of network using the GIS*. This would entail developing thematic graphs and evaluating the network using the GIS. This would require: (i) the purchase of GIS software; (ii) the provision of GIS training; and (iii) the collection of the GIS coordinates of all interstate and republican roads. A proper interface of the GIS and the road network databank should be created;

39. *Reconsideration of road condition definitions.* In its effort to improve the road database, the ARD has decided to take into consideration the current practice in the UK, as reported in the Highways Agency Network Management Manual.[23] During the process of modernizing its road database, the ARD should reconsider its definitions of road conditions. For example, under the current system, an interstate road with potholes in 0.3% of its surface area is considered to be in "good" condition. In most classification systems, a road with 0.3% potholes would be considered to be in "poor" condition;

40. *Measurement of the roughness of the paved roads.* Define a program for sustainable measurements of the roughness of all paved interstate and republican roads. Currently, the ARD measures roughness on only a fraction of the republican roads every year. To improve the accuracy of the measurements and facilitate the collection process, it is recommended that the ARD purchase one or two basic road roughness measurement equipments with laser technology;

41. *Measurement of road surface distress*. Define a program for sustainable measurements of road surface distress—for example, cracking and potholes. Currently, surface distress measurements are being done on interstate roads and only a fraction of the republican roads. It is desirable to define an appropriate level of detail for the measurements that are compatible with a network-level evaluation. It would be better to cover the entire interstate and republican road networks with basic indicators of surface distress, than to cover a fraction of the network with detailed indicators. Such measurements should be done annually, because they drive maintenance activities for the upcoming budget year;

[23] UK HA Network Management Manual: www.standardsforhighways.co.uk

42. *Measurement of pavement strength.* Define a program to use an FWD to characterize the pavement strength of paved roads. Most roads in Armenia were constructed using Soviet standards many years ago. There is limited knowledge of their pavement strength or the thickness of the pavement layers that compose the pavement. This kind of information—such as thickness of overlays and estimated road deterioration—is critical to define the periodic maintenance needs of a given road. If there are budget constraints, the characterization of the pavement strength of the roads could be done every four years—a quarter of the network every year—because deflections vary less with time, and are more difficult and expensive to collect;

43. *Measurement of traffic*. Define a program to measure traffic on the entire main road network. Currently, traffic is being measured systematically on only 10 points located on interstate roads, using permanent count stations—this is not satisfactory. This should be complemented with a program to define the traffic of all interstate and republican roads, which would require the purchase and use of portable traffic counts stations;

44. *Periodic updating of vehicle fleet characteristics and road-user costs.* Define a program to periodically update vehicle fleet characteristics and economic road-user costs that are needed to perform an economic evaluation of road agency alternatives. It is also necessary to define a program to periodically update the estimates of the unit costs of road works in economic and financial terms;

45. *Strengthen the RDCAD by providing training on various aspects of an efficient RAMS.* The Road Data Collection and Analysis Department should have adequate staff, secured budget and clear terms of reference that are included in the Annual Report. Training should include the following topics: (i) road network data collection processes; (ii) road network data management; (iii) network evaluation for monitoring, strategic planning, programming and economic evaluation of road works, and (iv) presentation of the evaluation using the GIS; and

46. *Review contents of the annual report*. This report should summarize the current road network condition, traffic, and safety, and present relevant maps, current and forecasted expenditures, monitoring indicators, and the expected performance of the network.

47. **Pavement design practice.** Premature pavement deterioration observed on some rehabilitated or newly constructed roads in Armenia may be the result, inter alia, of under-design—because actual truck axle loads have been reported to be heavier than estimates used by certain pavement designers. The ARD has adopted European and American practices on IFI-financed projects, but for its self-financed operations and for maintenance works, it continues to use Soviet era specifications; the university curricula and textbooks still use Soviet era designs, specifications, and test methods. The ARD should revisit its pavement design practice—especially for geometry and pavement structure—and its quality assurance approach, in order to limit premature pavement failures. Technical audits have been introduced for road works under IFI-financed projects, and these should also be extended for works under State budget financing.

C. Expenditures in the Road Sector

48. **Budgeting process**. The Law of Budgeting System regulates the budgeting process. The Government's expenditures on the transport sector are allocated under three main headings: (i) rehabilitation of roads; (ii) rehabilitation of transport structures (tunnels, bridges); and (iii) maintenance of roads (winter and routine maintenance). The MOTC, with the ARD's support, prepares the annual budget, three-year development plan for the road sector—and then submits it to the Government. After reviewing the proposed budget and making necessary adjustments, the Government submits it as a part of the general consolidated budget to Parliament for approval. All expenditures, including capital and operating expenditures, are made in accordance with the approved budget. The Government prepares an annual budget performance report in cooperation with the Ministry of Finance, and presents it to Parliament for approval. In general, actual budget expenditures in the road sector are in line with the approved budget. From 2005-2009, the Government focused more on rehabilitation of existing roads than on new construction—it spent 37% of its budget on rehabilitation of interstate roads; 40% on republican roads; and 23% on local roads.

49. **Road maintenance expenditures have remained very low in the past seven years, while rehabilitation expenditures have increased.** Table 7 presents consolidated expenditures on roads broken down by road improvements, rehabilitation, and maintenance, from 2005-2011.[24] The breakdown of maintenance expenditures between periodic and routine maintenance is not available. However, there is almost no periodic maintenance—thus, the bulk of expenditures are for routine maintenance. The Government spent approximately 0.2% of GDP annually on road maintenance from 2005-2011, an average of US$16 million per year. This contrasts with allocations of about 1% of GDP, which are normally seen in high-income countries with mature networks in good condition. The Government and IFIs increased rehabilitation expenditures from approximately 0.6% of GDP in 2005 (US$27 million), to 1.1% of GDP in 2010 (US$88 million). From 2005-2007, rehabilitation expenditures were fully financed by the domestic budget or grants for rehabilitation (mostly the latter). There has been a decline in Government-financed budget maintenance and rehabilitation expenditures since 2008, due to the financial crisis and the resultant significant decline in State revenue that has affected all sectors of the economy. From 2005-2011, the average total allocation for maintenance and rehabilitation expenditures was US$74 million per year—with peak values in 2009 and 2010, and a declining planned-value for 2011 (US$68 million). From 2009-2011, the average total allocation for maintenance and rehabilitation expenditures was US$94 million per year.

[24] Road improvements represent network development works, such as four-lane widening, upgrading and new construction works. Expenditures for 2010 and 2011 are planned and not actual.

Table 7. Investment Program on the Road Network from 2005-2011 (US$ million)

	Actual					Planned	
	2005	2006	2007	2008	2009	2010	2011
GDP (US$ million)	**4,900**	**6,384**	**9,206**	**11,917**	**8,714**	**8,269**	**9,673**
Improvement Works							
Government Budget	-	-	-	-	-		
IFIs	-	-	-	-	-		29
Total Improvement Works							***29***
GDP share %	***0%***	***0%***	***0%***	***0%***	***0%***	***0%***	***0.35%***
Maintenance and Rehabilitation Works							
Government Budget Rehabilitation	**27**	**35**	**57**	**41**	**36**	**30**	**11**
Rehabilitation of Interstate roads	5	16	25	11	16	9	3
Rehabilitation of Republican roads	17	16	7	24	14	11	6
Rehabilitation of Local roads	4	3	25	7	6	10	2
GDP share %	***0.6%***	***0.5%***	***0.6%***	***0.3%***	***0.4%***	***0.4%***	***0.1%***
Government Budget Maintenance	**10**	**13**	**21**	**22**	**14**	**17**	**18**
Maintenance of Interstate and	9	12	18	19	13	15	18
Maintenance of Local roads	0.7	1.1	1.5	1.5	-	2	
Others	0.4	0.5	0.6	0.9	0.6	0	
GDP share %	***0.2%***	***0.2%***	***0.2%***	***0.2%***	***0.2%***	***0.2%***	***0.2%***
IFIs Rehabilitation	**-**	**-**	**-**	**6**	**63**	**58**	**43**
Rehabilitation of Interstate &	-	-	-	6	63	58	43
Maintenance	-	-	-	-	-	-	-
GDP share %	***0.0%***	***0.0%***	***0.0%***	***0.1%***	***0.7%***	***0.7%***	***0.5%***
Total Maintenance and	**37**	**48**	**78**	**69**	**113**	**105**	**72**
GDP share %	***0.8%***	***0.8%***	***0.8%***	***0.6%***	***1.3%***	***1.3%***	***0.9%***

Sources: Government; World Bank.

50. Maintenance allocations for local and republican lifeline roads were insufficient; no funds were allocated for periodic maintenance of interstate and local roads. For routine maintenance of interstate and republican roads, a total of US$18 million was allocated by the MOTC in 2010—representing 14% of the total road sector budget, and resulting in an average allocation of US$4,380 per km. This allowed all 3,383 km of interstate and original republican roads to benefit from routine and winter maintenance—approximately 25% was spent on winter maintenance and 45% on patching; the latter can be as much as 70% for roads in poor condition. For 2011-2014, the planned routine maintenance expenditures are US$ 18 million per year. By contrast, no funds were allocated for periodic maintenance. However, for the State-owned local road network, routine maintenance funding was US$2 million for 3,319 km of local roads—including republican lifeline roads. This was equal to only 2% of the road sector budget and resulted in an average allocation of US$620 per km. These allocations for local and republican lifeline roads were insufficient, which resulted in only approximately half of the roads receiving winter maintenance and only 5-10% receiving summer maintenance. Calculations made by World Bank staff using the HDM-4 show that: (i) maintenance funding for interstate and

republican main roads will need to increase fivefold to cover the routine and periodic maintenance needs of the network: and (ii) routine maintenance funding for local and republican lifeline roads will need to be tripled in order to ensure proper maintenance—assuming that road conditions will continue to improve as a result of rehabilitation.

51. The community-owned local road network receives hardly any maintenance allocations, because it is funded from local revenue—which is very low. There is an allocation of US$8.9 million from the central budget, but this is allocated to major cities—in 2010, all of this funding was allocated to Yerevan. Although the community-owned network refers mainly to the smaller roads within the community, it also includes the State-owned local roads where these pass through the communities. As a result, the *marzes* only maintain the local roads under their responsibility up to the boundaries of the communities—winter maintenance by the contractors hired by the *marzes* is generally carried out inside the communities as well, but summer maintenance does not include the community sections. There is generally little funding available for the communities, except for the major cities—but very little of that revenue is spent on the local roads, and priority is given to urban roads. They have no revenues of their own, but receive a fixed percentage of collected taxes—100% of land and property taxes, 15% of income and profit taxes and certain duties and fees. They receive financial equalization and other subsidies from the Central Government, which are discretionary, but also earmarked subventions.

52. Road development works on the North-South corridor could undermine the allocation of funds for maintenance and rehabilitation of the network (Box 1). In 2010, IFIs started financing road improvements on the North-South corridor—with ADB-financing of the North-South Corridor Development Project that reconstructs to international standards and adds capacity to sections of the North-South corridor between Yerevan and Gyumri. The financial requirements of extending this program to other sections of the North-South corridor are high, and could decrease the allocation of funds for maintenance and rehabilitation of the network. Under budget constraints, development works are warranted only if they pass a rigorous economic evaluation.

Box 1: North-South Corridor

The ADB approved a US$500 million Multitranche Financing Facility (MFF) for the North-South Road Corridor Development Program on September 8, 2009, to finance the improvement of the 550-km road corridor, modernize border and customs infrastructure and facilities, and implement the road subsector strategy in Armenia. Project 1 will reconstruct an 18.4 km 4-lane section of the Yerevan-Ashtarak road and improve road safety at Yerevan-Ararat road; Project 2 will widen the 41.3-km, Ashtarak-Talin Section; Project 3 will widen the 44-km Talin-Gyumri Section from a 2-lane to a 4-lane standard. The subsequent projects are expected to include the upgrade and and/or rehabilitation of the remaining parts of the North-South road corridor.

In October 2009, the ADB approved the North-South Road Corridor Investment Program - Project 1 for US$70 million to reconstruct the 18.4 km four-lane section of the North-South corridor from Yerevan-Ashtarak, with an estimated closing date of June 2014. In October 2010, the ADB approved the North-South Road Corridor Investment Program - Project 2 for US$210 million to reconstruct approximately 41.3km of the two-lane road section between towns of Ashtarak and Talin, and widen it into 4-lane road standards, with an estimated closing date of June 2015. Up to December 31, 2010, consultants for construction supervision of Project 1 and preparation of Projects 2 and 3 of the MFF have been recruited, and the total contract awards total US$3.6 million. Procurement for the civil work has not been completed, and rebidding for the first civil works contract for Project 1 may be required.

Maintenance and Rehabilitation Requirements on Interstate and Republican Roads

53. The World Bank has undertaken an assessment of required expenditure levels for the maintenance and rehabilitation of interstate and republican roads, in order to compare actual and projected expenditures. To this end, the HDM-4 Model (Box 2) has been used to measure the performance of roads managed by the ARD under several different maintenance and rehabilitation standards. The HDM-4 evaluation provides indicative figures of the maintenance and rehabilitation needs of the network, and an example of the type of evaluation that should be undertaken by the ARD when developing its annual business plans. To obtain more precise results, the Study recommends that this type of network strategic evaluation be repeated in the near future using the network data being collected in 2010 by the ARD. This refined network strategy evaluation could include an estimation of the network maintenance, rehabilitation and development needs, such as capacity improvements.

54. **The HDM-4 assessment was based on a number of assumptions—four different scenarios were depicted**. The basic assumptions included: (i) a 5% traffic growth rate per year; (ii) a 12% discount rate; (iii) a 20-year evaluation period; (iv) unit costs of road works based on current average road work costs in Armenia; and (v) average unit road-user costs based on current average vehicle fleet characteristics for Armenia. The four scenarios are as follows:

- *Option 1: "Minimize total transport costs scenario".* This scenario selects the maintenance standard per road class that minimizes the present value sum of road agency costs plus road-user costs over the evaluation period (total transport costs). It achieves a target of attaining 72% of main roads in good or fair condition by 2020;

Box 2: Highway Development and Management Model (HDM-4)

The Highway Development and Management Model (HDM-4) simulates total life-cycle conditions and costs for one road, a group of roads with similar characteristics, or an entire network of paved or unpaved roads, for a series of road agency construction or maintenance standards, and provides the economic decision criteria for evaluating the standards being analyzed. The primary costs computed for the life-cycle analysis include the costs of road construction and maintenance and vehicle operating costs, to which travel-time costs and accidents can be added. The costs of construction-related traffic delays and environmental pollution can be entered in the model exogenously, based on separate estimates. The HDM-4 contains a budget constraint optimization module to find the best way of using road agency funds under budgetary constraint.

The broad concept of the HDM-4 model is quite simple. For a given road and series of user-specified road agency standards, three interacting sets of costs (related to the construction, maintenance and road users) are added together over a defined evaluation period in discounted present values, computing the resulting present value of total transport costs—where costs are determined by first predicting physical quantities of resource consumption and then multiplying these by unit costs or prices. Economic benefits are then determined by comparing the total transport costs for the various standards with a base standard (null alternative) usually representing minimal routine maintenance. The optimal standard is the one with lower total transport costs or higher net benefits compared with the base standard. The user obtains net present values, rates of return and other economic indicators needed to compare the standards and prioritize road works.

Within the planning, budgeting and programming functions of a highway agency, the HDM-4 model may therefore be used to establish:

- Desired budget levels that would minimize the total costs of road transportation;
- Appropriate policies and standards for construction and maintenance programs that are consistent with minimizing total transport costs under existing resource constraints;
- Long and medium-term investment and maintenance programs; and
- Appropriate economically-derived intervention criteria to develop short-term programs and annual budgets, based on an appropriate pavement management system.

The model contains road deterioration, road works effects and road-user costs relationships derived from extensive research done in developing countries over the past 30 years which was carried out collaboratively by the World Bank and major research institutions and highway administrations. An important feature of the model is the analytical support it can provide to make a convincing case to legislatures and top decision-makers for adequate maintenance funding to preserve the road infrastructure.

Source: World Bank. See www.hdmglobal.com

- *Option 2: "Expenditures of US$110 million per year scenario".* This scenario takes into consideration maintenance and rehabilitation expenditures on the network in 2009, with 67% of roads in good or fair condition by 2020.

- *Option 3: "Eliminate rehabilitation backlog in 10 years scenario"*. This is a budget-constrained scenario that eliminates the rehabilitation backlog in 10 years, with 65% of roads in good or fair condition by 2020; and

- *Option 4: "Keep current road condition scenario"*. This scenario takes into consideration the current condition of the road network and assumes that this condition will be maintained in the future, with 50% of roads in good or fair condition by 2020.

55. Table 8 presents a summary of the HDM-4 analysis. It presents the results of each of the four scenarios in terms of the present value—at a 12% discount rate—of road agency, road-users and total transport costs, and how this will affect the network condition and the road network asset value in 2020. Armenia will not be in a position to finance the maintenance and

rehabilitation of its main roads along the lines of the "minimize total transport costs scenario", despite its high economic benefits. This is because that scenario would entail rehabilitation and rehabilitation contracts on about 770 km of roads every year for five years, which is beyond the ARD capacity for contracting road works. In comparison with the "keep current road condition scenario", the ARD would increase the present value of road expenditures by US$71 million if it were to select the "eliminate rehabilitation backlog in 10 years scenario". However, this option would be beneficial for road-users, because every dollar the road agency spends under this scenario would decrease road-user costs by 2.5 times. That fact provides a strong argument for increasing the expenditures made by the ARD, because the benefits in terms of reduced road-user costs exceed the additional expenditures required.

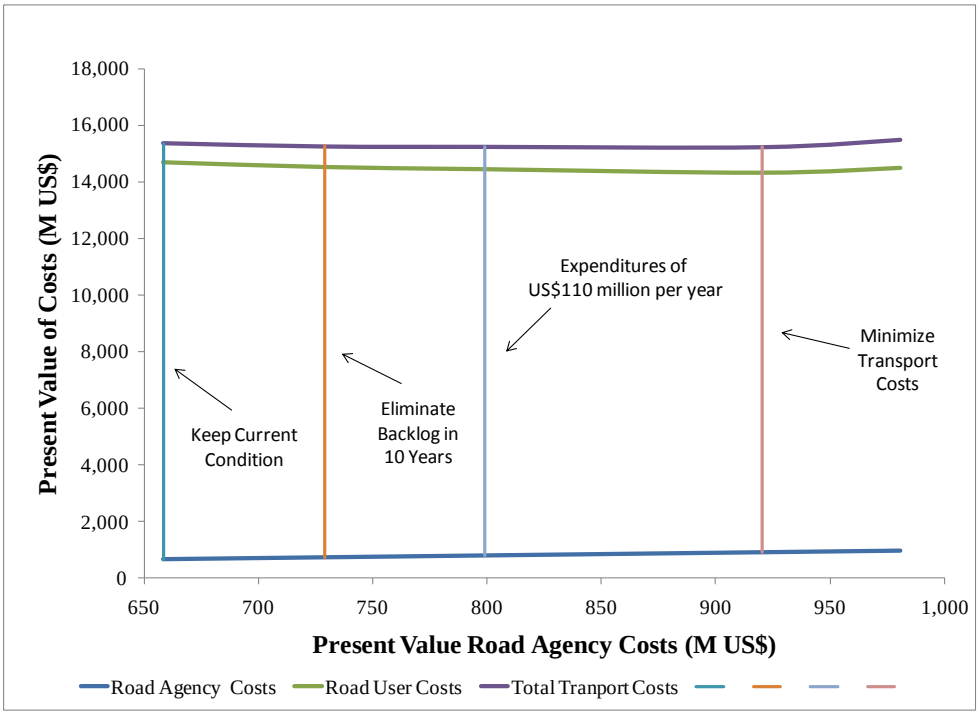
Table 8. Consequences of Different Expenditure Scenarios

Scenario	Present Value of Costs			Network condition	Asset Value in 2020	
	Road Agency	Road-users	Total		US millions	Percentage
Minimize total transport costs	920	14,308	15,229	72	3,343	15%
US$110 million per year	799	14,441	15,240	67	3,338	15%
Eliminate backlog in 10 years	729	14,524	15,253	65	3,300	14%
Keep current road condition	658	14,704	15,362	50	3,084	6%

Note: Network condition refers to the percentage of republican and interstate roads in good or fair condition in 2020.
Source: World Bank.

56. Figure 5 presents the present value of road agency costs, road-user costs, and total transport costs of the four different expenditure scenarios. Although the ARD spends less with the "keep current road condition scenario", the total transport costs are higher. The "expenditures of US$110 million per year scenario" leads to significantly better road conditions than the "keep current road condition scenario". The total expenditures on interstate and republican roads has been projected to reach only US$68 million by 2011. However, the HDM-4 analysis suggests that US$98 million should be spent annually in the next five years in order to eliminate the rehabilitation backlog in 10 years. Thus, the funding gap is US$30 million—if the gap were to be covered by a fuel levy, it would need to be US$6 cents per liter. Further details on each of the scenarios can be found in Annex 6.

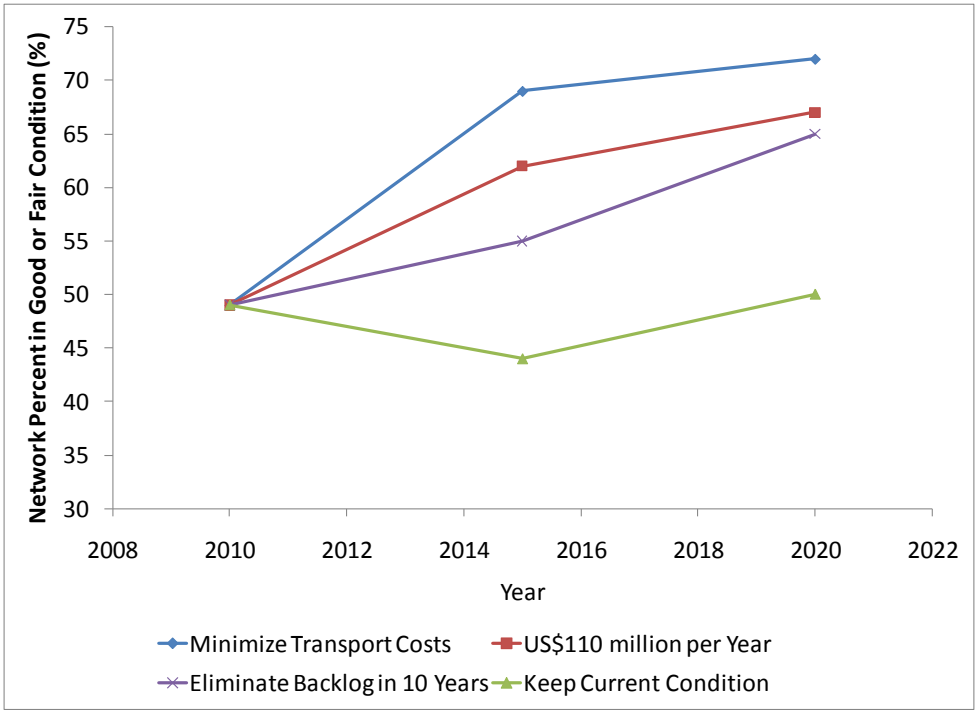
Figure 5. Present Value of Total Transport Costs (US$ million)



Source: World Bank estimates.

57. **Network condition and asset value.** Different levels of expenditure over a certain number of years would clearly have an impact on the eventual condition of the road network. Figure 6 presents the impact of the four different options on the road network condition in 2015 and 2020. Only 49% of interstate and republican roads were in good or fair condition in 2010; by 2020 this would rise to: (i) 72% for the "minimum total transport costs" option; (ii) 65% for the "eliminate backlog in 10 years" option; and (iii) 67% for the "expenditures of US$110 million per year" option. The "minimize total transport costs" option would increase the road asset value from the current US$2,903 million by 15%—to US$3,343 million—by 2020. This compares with a 14% increase—to US$3,300 million—under the "eliminate the backlog in 10 years" option.

Figure 6. Interstate and Republican Roads – Percentage of the Network in Good or Fair Condition (%)



Source: World Bank estimates

Recommendations

58. **There is a need to raise expenditures on international and secondary roads in order to address the rehabilitation backlog**. Tackling the rehabilitation backlog over a 10-year period would require an annual expenditure of US$98 million—thereafter, it would require an annual expenditure of US$74 million. At a minimum, it is important to ensure that these funds are allocated to routine and periodic maintenance—which have been underfunded in the past. Table 9 presents a summary of the analysis under the four scenarios in terms of the required expenditures, and how this would affect the network condition in 2015 and 2020.

Table 9. Funding Requirements of Different Expenditure Scenarios

	Roads in Good or Fair Condition in 2015 (%)	Roads in Good or Fair Condition in 2020 (%)	Annual Expenditures in First 5 Years	Annual Expenditures for Next 15 Years	Present Value of Expenditures (20 years)	Financing Gap in First 5 years
Option 1	69	72	170	59	920	102
Option 2	62	67	110	73	798	42
Option 3	55	65	98	74	742	30
Option 4	44	50	82	62	658	14

Note: Financing gap in relation to the 2011 planned expenditures (US$68 million)
Source: World Bank staff estimates

D. Options for Sustainable Road Management Financing

59. Additional resources will need to be found for financing the maintenance backlog. This can be addressed by improving the efficiency of resource allocation, improving the prioritization of works, and generating additional revenues. These possibilities are discussed below:

Option 1: Increase Efficiency of Current Expenditures

60. **Road maintenance and network improvements can be more efficiently implemented by determining priorities through the use of a RAMS.** This will help: (i) to determine the appropriate level of maintenance activities required and the cost per road link; (ii) to prioritize activities with regard to the available budget and any additional revenues; and (iii) to improve contracting efficiencies. Reducing less productive expenditures and redirecting funds to higher priority projects can help expedite the development and maintenance of important roads. Road development works—such as widening and upgrading—should be implemented only after passing a rigorous economic evaluation, using tools such as the HDM-4. The ARD can also increase the available resources for maintenance by improving its planning and implementation of road contracts—by, for example, minimizing cost overruns through better design and proper control during contract execution.

61. **Introduce improved road construction and maintenance technology.** There are a number of options for introducing improved road construction and maintenance technology in Armenia. For example, the use of crushed stone bases rather than bitumen bases can greatly reduce the cost of rehabilitation works. Other options include: (i) the use of in-place recycling rehabilitation works; and (ii) the use of cement concrete roads (Box 3).

Box 3: lmproved Road Construction and Maintenance Technologies

Highway surface pavements types can be categorized into two major groups: (i) flexible; and (ii) rigid. Flexible pavements are surfaced with bituminous materials, and rigid pavements are composed of a Portland cement concrete surface course. The structure of bituminous pavements generally tends to deflect or flex under repeated traffic loading. Concrete pavements are significantly "stiffer" than bituminous pavements—and they can use reinforcing steel or other materials in order to eliminate cracking. Bituminous pavements generally require maintenance or rehabilitation every 10-15 years, and are relatively easy to construct. It requires a couple of weeks to build concrete pavements—and they can often serve 20-40 years with little or no maintenance or rehabilitation. Thus, the latter are often used for urban and high traffic roads. However, there are trade-offs. For example, when a bituminous pavement requires rehabilitation, the options are generally less expensive and quicker to perform than for a concrete pavement. Generally speaking, there are many factors to consider before selecting one type of pavement over another. The selection is typically done on the basis of economics, policy, politics, or a combination of the above. A life-cycle cost analysis is an essential economic evaluation tool that provides guidance to transportation officials regarding the selection of a pavement type. Because of the availability of concrete in Armenia, rigid pavements are an attractive option for high-traffic roads and cobblestone pavements are an attractive option for low-volume roads.

The construction of crushed-stone bases and sub-bases involves the following steps: (i) manufacturing of the material from a gravel pit or quarry; (ii) transportation to the grade; (iii) placement; and (iv) compaction. The material is initially tested for general quality and for gradation and uniformity of these characteristics. If a stiffer base is needed, base courses can be constructed that add various bituminous mixtures to the crushed-stone base. In relation to the surface course, bituminous bases usually contain larger maximum aggregate sizes, are more open–graded, and are subject to less tough specifications. In general, it is cheaper and of lower quality than the surface course. Bituminous bases are typically required for high-traffic bituminous roads, whereas crushed-stoned bases are sufficient for moderate and low-traffic levels. A life-cycle cost analysis considering the costs of materials should be performed to provide guidance on the selection of base types. In Armenia, due to the relatively low traffic on the roads, crushed-stone bases are an attractive option.

Road works rehabilitation typically entails removing the current pavement layers and replacing them with new materials. Recycling construction methods reuse part of the existing materials on the site or elsewhere, while maintaining the same construction quality. The recycling of existing materials allows for substantial savings in cost and time-achieved, while protecting the environment, conserving non-renewable resources (such as bitumen and aggregate materials), permitting single-lane repair, and minimizing traffic disruption. On the other hand, rehabilitation techniques may require an initial investment for specialized equipment. In Armenia, due to the high quantity of rehabilitation works needed, the use of recycled materials is an attractive option.

Source: World Bank.

Option 2: Develop Cost-effective Design Standards for Low-traffic Roads

62. **The standards used to rehabilitate local roads are higher than justified by the level of traffic.** Thus, the limited financial resources wind up being allocated to the rehabilitation of a few segments of roads, which increases total transport costs without improving the overall quality of the network. For example, rehabilitating a low-volume road with an overlay of 80mm instead of 50mm will increase the rehabilitation costs by around 40% and also increase the present value of total transport costs (road agency plus road-user costs) over a 20-year evaluation period by 2%. Thus, overdesign standards penalize road-users in the long run. The design standards should also be reviewed to allow for more cost-effective designs for roads carrying

lower traffic volume. Utilizing thinner asphalt, surface dressings and slurry seals as well as gravel pavements are all options that could be considered to provide good accessibility at a lower cost.

Option 3: Increase Road-user Charges

63. **Revenue could be increased by introducing additional user charges—for example, higher fuel taxes**. In general, a large portion of a government's general revenue comes from taxes and charges levied on transport, vehicles, and fuel. Transport-related charges and taxes are generally fed into general government revenues. Worldwide revenues from the road sector average 3% of GDP; revenues derived from road-users generally exceed spending in the sector by a 2-to-1 average margin in Western Europe and by as much as a 3-to-1 margin in some countries[25]. By contrast, revenue from the transport sector in Armenia in 2009 averaged only 1% of GDP. The level and structure of road transport taxation should be governed by economic considerations relating to efficient infrastructure charging and environmental effects. This implies that road-user charges should ensure that individual travel and transport choices approximately reflect the cost that road-users impose on others over and above the private costs of operating motor vehicles.

Table 10. Gasoline and Diesel Prices (US cents per liter, unless otherwise stated)

	US cents per liter (Nov 2010)		US dollars
	Gasoline	Diesel	GDP Per Capita
Albania	146	140	3,616
Armenia	**108**	**99**	**2,677**
Azerbaijan	75	56	5,765
Bosnia and Herzegovina	142	142	4,158
Bulgaria	151	158	5,955
Czech Republic	175	169	18,722
Georgia	113	113	2,560
Germany	190	168	40,512
Hungary	167	161	13,210
Kazakhstan	71	51	8,327
Moldova	121	108	1,503
Netherlands	213	171	46,418
Poland	157	150	11,522
Romania	146	146	7,391
Russian Federation	84	72	10,522
Serbia	150	148	5,262
Slovak Republic	170	153	15,906
Turkey	252	203	10,207
Ukraine	101	92	3,003
United Kingdom	192	198	36,298

Note: Retail prices as of November 2010, when crude oil prices were US$81/bbl BRENT. This is equal to 51 US cents per liter.
Sources: GIZ available at **www.gtz.de/fuelprices**; IMF, World Economic Outlook, October 2010.

[25] Source: International Road Federations' World Road Statistics 2004

Box 4: Setting the Level of Taxation for Road-users

Excises on motor fuel and motor vehicles can be rationalized as proxies for the cost of government-provided road services. Road and transport services resemble goods produced in the private sector that are used optimally when their price—commonly referred to as the economic-user charge—equals the total social costs of constructing and operating the road network. The social costs of road transport include the following categories:

- Physical wear and tear caused by motor vehicles using the roads: fuel and license fees, particularly for heavy trucks, can be designed to charge users for these costs.
- Environmental costs on account of air pollution: urban lead that harms health, nitrogen oxides that contribute to acid rain, and carbon dioxide that causes global warming. (Differentiated) fuel excises are the most suitable instrument for charging road-users for air pollution costs.
- Injury and property costs due to traffic accidents. (Probably the best instrument is a tax on car insurance premiums)
- Congestion costs in urban environments, where nearly 60% of the country's inhabitants reside. Usually, this is the subject of regulation rather than taxation.

There is little doubt that developing countries should raise taxes on road transport to reflect the social costs of road use. Beyond this, the case for using road transport for revenue-raising purposes—over and above the social costs—could be strong for Armenia and Georgia, because the economic and administrative costs are lower than for other taxes. The distortionary impact on private sector activity tends to be limited. However, in the absence of a detailed examination of the social costs of road use and an evaluation of the difficult trade-offs and compromises needed in view of the multiplicity of objectives, it is difficult to provide specific recommendations regarding the extent to which the taxation of road transport should be increased. Basically, the Study's analysis can be used as a starting point for further discussion and research.

Adapted from the World Bank Report on Tax Policy in Kazakhstan (2007)

64. The most widespread form of charging users throughout the world is through a surcharge on the consumption of fuel—it relates to road usage, is easily recognizable, and is simple to administer. The financing of roads and highways infrastructure via fuel taxes is the primary pricing policy instrument worldwide. According to a recent report by the GTZ, a global average of 80-90% of all transport sector revenues is raised via fuel taxes.[26] In the USA, fuel taxes of about 10 US cents per liter of diesel and gasoline are levied to cover all direct expenditures for roads and highways—including maintenance, refurbishment, new construction, and capital recovery for the roads and highways departments. In November 2010, the US price for diesel was 76 US cents per liter, and the price for super gasoline was 84 US cents per liter (Table 10). In Armenia, those prices are 108 US cents per liter for gasoline, and 99 US cents per liter for diesel. These are lower than the comparable prices in Georgia or Moldova, which have a lower GDP per capita level—which suggests that such fuel price increases, if warranted, could still pass affordability considerations. The performance review done under Armenia Thematic Analysis 2008-2012[27] found that the current fuel taxation in Armenia: (i) has resulted in declining fuel tax revenues—due to quantity-based presumptive taxation and the recent decline in the volume of imported gasoline; (ii) has increased inequity in terms of the tax burden; and (iii) has probably led to a less efficient allocation of resources.

[26] GTZ (2009), *International Fuel Prices 2009*. Available at: http://www.gtz.de/de/dokumente/gtz2009-en-ifp-full-version.pdf.
[27] Armenia Thematic Analysis 2008-2012 Volume II, Europe and Central Asia Region, The World Bank, June 2008

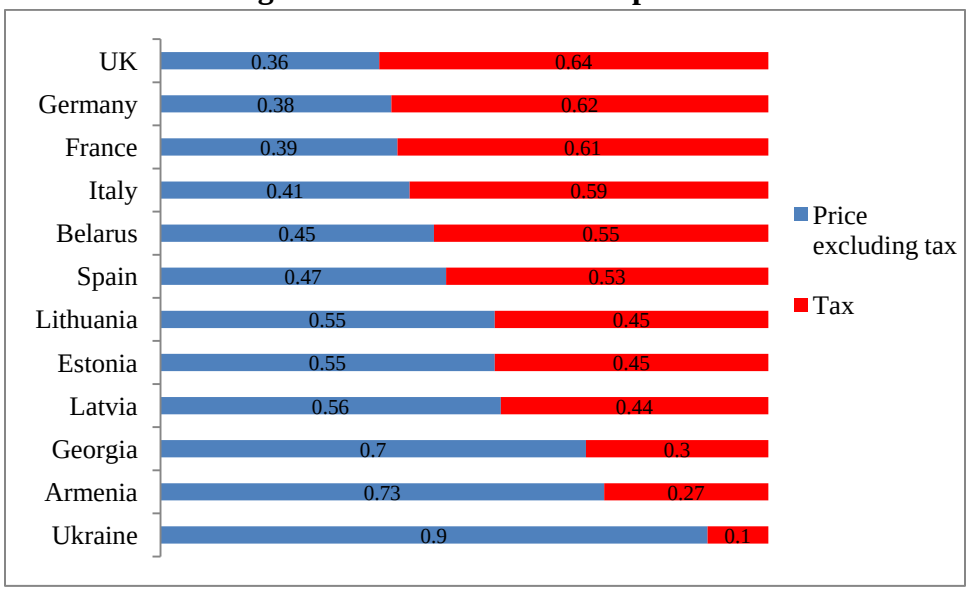
Table 11. Fuel Taxes in Armenia, Effective from January 1, 2011

	Taxation Base Unit	Excise Tax Rate	VAT
Gasoline*	1 ton	AMD 25000	20%
Diesel	1 ton	AMD 32500	20%

*Sum of VAT and excise tax per 1 ton of gasoline cannot be less than AMD 112000.
Source: Armenia Tax Laws

65. The low level of fuel taxes is reflected in comparative data on gasoline price composition. As shown in Figure 7, gasoline excise taxes comprise more than 60% of end-user prices in France, Germany, and the UK. However, in Armenia, the Ukraine, and Georgia they comprise 30% or less of end-user prices.[28] In Armenia—unlike most European countries—the use of compressed natural gas reached an estimated 42% of road-users in 2007. This means that fuel taxes on gasoline and diesel are less important as a source of revenue for Armenia. The issue of revamping excise taxes in Armenia is being analyzed in the forthcoming Fiscal Consolidation and Recovery report[29]. The latter indicates that improving the excise taxes would yield a significant amount of revenue, in part by eliminating leakages. A detailed analysis on all road taxes should be conducted in Armenia to properly compare road taxes with similar countries, and to consider other details such as indexation for inflation.

Figure 7. Gasoline Price Composition



Source: World Bank estimate

28 There was a major switch in fuel use, with compressed natural gas becoming a key fuel used in transport, and estimated to account for 42% of the market by 2007.

[29]Forthcoming Republic of Armenia Fiscal Consolidation and Recovery Report, Poverty Reduction and Economic Management Unit, Europe and Central Asia Region, the World Bank, 2011.

Option 4: Earmarking

66. **One option for financing road works is by earmarking, through the creation of a road fund—although this approach has often been associated with inefficiencies.** The pros and cons of earmarking have been debated at length.[30] Some argue that the Government is the best judge to decide how revenues should be allocated and that it is wrong to earmark taxes for specific purposes. Others have taken the view that, given the urgent needs of the road sector, users would benefit from paying higher taxes related to road use, provided that the extra revenue was actually spent on roads. Slovenia took the latter approach for developing its motorways. A number of countries have attempted to earmark part of their road-user revenues in order to guarantee a certain level of funding for roads. Five of the EU accession countries—Bulgaria, Latvia, Romania, the Slovak Republic, and Lithuania—did this through the creation of a road fund (Lithuania subsequently abolished its road fund on January 1, 2002). By contrast, Estonia and Slovenia have earmarked part of their fuel tax for roads, without establishing a road fund. Unfortunately, the difficult budgetary situations faced by most of these countries has resulted in a much lower proportion of funds than legally earmarked actually going to the road sector.

67. Armenia has plans to earmark additional resources through legislation requiring fuel taxes (10% on petrol and 10% on diesel) to be used for routine maintenance.[31] The Study found that earmarking funds for routine and periodic maintenance on a pilot basis could provide a good 'test' of its impact assessment demonstrating that the element of entitlement is put to good use. Routine and periodic maintenance is particularly suited to earmarking because: (i) these functions have the highest priority in terms of road expenditures because they are very cost-effective; (ii) there is already experience with respect to contracted routine maintenance and the shortcomings related to the levels and predictability of funding; and (iii) different assessments of the quality of contracted maintenance have identified potential benefits from larger contracts and the inclusion of local roads in those contracts.

Option 5: Borrowing

68. **Borrowing—whether domestic or external—implies the need to repay, and thus raises the question of whether the return on the expenditure justifies the cost.** Perhaps just as relevant is the question of whether the spending financed through borrowing will enhance future Government revenues that can be used to finance the repayment of the loan. The World Bank has deemed as appropriate the level of borrowing presented in the Government's planned investment program, in the context of an assessment of the overall sustainability of the Government's debt obligations—in terms of its capacity to service interest and principal repayments. This assessment considered, *inter alia*: (i) the economy's prospective growth rate—its growth potential for exports and remittances; (ii) the prospective interest rate environment; (iii) the

[30] See, for example, Creightney 1993, De Richecour et al. 1995, Gwilliam and Shalizi 1997, Heggie and Vickers 1998, Malmberg Calvo 1998, Bousquet and Queiroz 1996, Potter and Barry 1997.
[31] This is currently a draft proposal for approval by the Parliament.

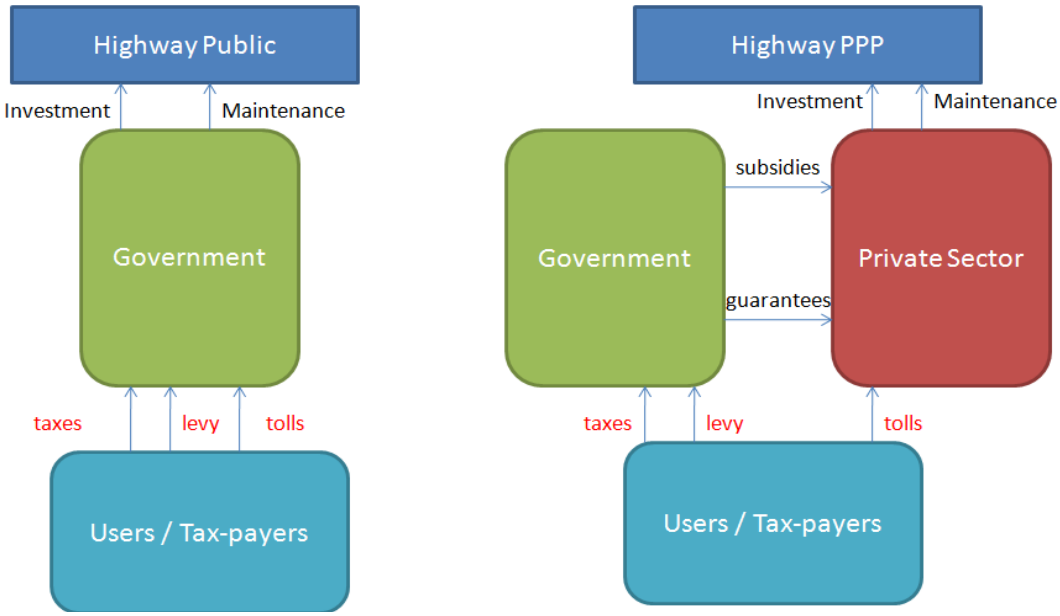
elasticity of revenue to growth; (iv) the composition of existing debt in terms of interest rates, maturity, and currencies of borrowing; and (v) the terms of any new debt being considered. Borrowing to finance recurrent costs such as routine maintenance is unlikely to be a viable strategy, because it would quickly build up debt that would then need to be serviced. The optimal policy is to borrow for higher return capital works—such as rehabilitation, and to a certain extent periodic maintenance—rather than to borrow for new construction or improvement works.

Option 6: Mobilizing Private Sector Resources through Public-Private Partnerships

69. **Most current forms of PPPs do not appear to be realistic mechanisms for financing roads.** PPPs provide an alternative partnership model in-between the public and private sectors, in which a private firm provides a global service with sufficient autonomy and incentives to produce efficiency gains for the benefit of all parties—and in particular, of road-users. Numerous forms of PPPs have been developed worldwide to respond to the various fields of application—the major categories of PPPs for roads are presented in Annex 2. Unfortunately, PPPs do not appear promising in the Armenian context due to: (i) a low traffic volume, which increases the financial burden on either the concessionaire or the Government[32]; (ii) an inadequate legal, technical and financial capacity to prepare and implement PPP projects; (iii) tightened credit conditions and a weak investment climate; (iv) governance concerns; and (v) the absence of access-controlled roads. It would be difficult for any private firm to generate a suitable rate of return from an investment in Armenia's road sector—which would necessitate a significant Government guarantee. When public authorities consider using PPPs to bridge the infrastructure financing gap, they need to ensure that the PPP option is cheaper in the long-term than traditional procurement and public sector financing—taking into consideration all forms of contingent liabilities.

[32] If the concessionaire was willing to assume traffic risk, low traffic volumes would mean lower revenues and potential difficulties in meeting debt service requirements. If the Government were to bear the traffic risk by agreeing to an availability payment, it would lose some of the toll revenue it had budgeted.

Figure 8. Financing Sources for Highways Funded from Government and PPPs (Concession)



Source: World Bank.

70. The Government should consider using PPPs for road maintenance and rehabilitation works through multi-year performance-based contracts for key interstate roads.[33] These types of contracts make it possible for the Government: (i) to transfer the construction risks to the contractor; and (ii) to ensure optimum management of a section of a road or road network over a long period—up to 10 years. Current performed-based contracts used in Armenia include only maintenance. Contracting maintenance and rehabilitation works together is a more efficient way of managing road assets. It can lead to improved road conditions, reduced public spending over the long-run, and improved construction standards, by encouraging more innovation and greater use of modern techniques and equipment. The benefits from a long-term maintenance and rehabilitation contract would include some of the key attractions of a typical PPP scheme: good value-for-money, efficiency gains, and building of local capacity. It would also help preserve a road network in need of urgent maintenance and rehabilitation attention, generate employment in the construction industry, and make it possible to earmark funds for the road sector. The introduction of multi-year performance-based contracts would require amending the current procurement law—because the mechanism of periodic tendering under the current law does not allow for contract terms longer than one year, without making annual agreements.

71. Without a significant financial contribution and risk born by the State, a build-operate-transfer scheme or concession for a toll road seems unrealistic for Armenia in the short-term. In the current economic environment, private sector companies would probably be unwilling to

[33] Armenia: Private Participation in the Road Sector, World Bank Guidance Note prepared by Jukka-Pekka Strand and Vickram Cuttaree, March 2011, Washington D.C.: World Bank.

assume any traffic risk, thus requiring considerable Government financial support. As a result, the cost of making a toll road project bankable would likely be high, and raise affordability concerns for the Government. It would also be challenging for the Government to prepare and implement a PPP project with limited local capacity and experience. The Government would have to commit considerable resources to feasibility and other studies, and hire reputable financial, legal and technical advisors. At this time, it would be more advisable for the Government to start building capacity in commercial, legal and financial PPP aspects through smaller-scale projects, such as maintenance and rehabilitation contracts as discussed above.

Box 5: Experience with PPPs in Central and Southeastern Europe

The first attempts to implement PPP projects in the transport sector in Central and Southeastern Europe faced obstacles that frequently led to delays, protracted negotiations, renegotiations, and cancellations. Among privately managed road projects, several factors contributed to these problems:

Lack of robust feasibility studies. Most of the unsuccessful projects lacked a solid feasibility study carried out before procurement. For example, in the case of the Zagreb–Macelj Toll Motorway, financial viability discussions were not held until negotiations were underway with the selected consortium. The negotiations failed to reach financial closure as a result of disagreements between the Government and the consortium on the public sector contribution.

Overly-optimistic traffic forecasts. In the early years, overly-optimistic traffic forecasts hurt several concessionaires, because they bore the demand risk. In the absence of minimum traffic or revenue guarantees, lenders sometimes requested an independent traffic review, which delayed and sometimes prevented financial closure. In other cases, concessionaires had to bear the cost of lower traffic, which often led to financial distress. Projects that failed or never materialized because of lower-than-expected traffic include: (i) the Czech Republic D5 motorway in 1993; (ii) the M1/M15 toll road in Hungary; (iii) the Pitesti–Bucharest–Constanza motorway in Romania; and (iv) the A4 Zagreb–Gorican motorway in Croatia.

Public resistance to tolls. With a PPP scheme—and in the absence of shadow tolls—users were required to pay a larger share of the costs, in a region where road use had largely been free. In some cases, users responded to tolls by switching to parallel roads, which further contributed to traffic and revenue shortfalls. And in some cases—such as the M1/M15 highway in Hungary and the Trakia motorway in Bulgaria—increases in toll rates, even when justified by inflation or traffic levels, led to legal action or public resistance.

Changing financial support mechanisms. In response to public resistance to tolls, some governments introduced a vignette system, whereby the toll is collected by selling motorway stickers (***vignettes)***. In Hungary, direct tolls on the M5 Toll Motorway Project were replaced by a general motorway vignette, and the payment of availability fees to the concessionaire. These shifts transferred a significant traffic risk burden to the public sector. Moreover, to make it politically acceptable, vignette rates were set at levels that were too low to compensate for the heavy capital investments undertaken. In Poland—where the vignette system was introduced for the national road system in 2006—the State has been unable to settle a dispute with the concessionaire for the A4 Toll Motorway Project on the level of compensation for lost revenue.

Noncompetitive procurement. Many countries started their road concession programs with limited competition and sometimes (often after a change in government) had to cancel negotiations or renegotiate. Without competitive procurement, negotiations typically take longer and can result in lower value for money. International financial institutions—because of their procurement rules—were prevented from advising on the structuring and co-financing of projects, which led to unnecessary delays and cost increases.

Subsequent revision of the legal and regulatory framework. Projects were often implemented in isolation from the sector policy—with the need for specific laws or regulations considered late in the process. In the A1 Toll Motorway Project in Poland, the decision to amend the Toll Motorway Act—which defined the legal framework for private participation in the sector—was made only at the procurement stage. That was one of the reasons why it took nearly seven years to advance from selection of the concessionaire to signature of the concession agreement.

Source: Cuttaree, Vickram, Martin Humphreys, Stephen Muzira, and Jukka-Pekka Strand. 2009. *Private Participation in the Transport Sector: Lessons from Recent Experience in Europe and Central Asia*. Transport Paper TP-24, June 2009, World Bank, Washington, DC.

Conclusions and Recommendations

72. As part of a wider transport sector dialogue with the Government of Armenia, the World Bank has conducted a performance review of road maintenance and rehabilitation management to identify the key financing, policy and institutional drivers for effective and sustainable management of the road network. Based on a thorough diagnostic, the Study develops a set of recommendations aimed at improving the sustainability of road management and financing, in order to achieve the overall objective of modernizing the road network.

Road Network

73. For the purposes of the Study, the road network refers to interstate, republican, and local roads—including the roads classified as lifeline roads that have been officially reclassified as republican roads—with the urban road network excluded from the analysis. The condition of the majority of the road network remains poor, with the exception of interstate roads. Transport costs are high, and connectivity to markets poor, due to degraded rural infrastructure. Whereas over 80% of interstate roads are in good or fair condition, this is true of only 33% of republican roads, and only 13% of local roads. This reflects under-spending on republican and local roads, as the Government has prioritized expenditures on interstate roads. The current asset value of the entire road network is estimated to be only one-third of what it would have been if there had been proper maintenance in recent years.

Institutional Setup

74. In general, the road management structure currently in place appears adequate for management of interstate and republican roads. The latter are under the responsibility of the MOTC, delegated to the ARD. However, a key issue that needs to be resolved is to unequivocally designate to a single entity the responsibility for maintaining republican lifeline roads. The transfer of local lifeline roads has meant a nearly 70% increase in the road network under the direct responsibility of the MOTC, but the latter has not received additional funding from the Ministry of Finance to reflect this increase in responsibility. As a result, maintenance of these roads has been effectively handed back to local administrations (*marzes)*, who lack sufficient funding for maintenance. The responsibility for maintenance of community-owned sections of local roads also needs to be explicitly designated, although this would not necessarily involve a change of ownership. The responsibility for the maintenance of lifeline roads must first be properly defined, before the other recommendations described in the Study can be effectively implemented.

Road Maintenance

75. Routine road maintenance is carried out under performance-based contracts (PBCs). This means that maintenance payments are made on the basis of the condition of the roads and the

amount of inputs used, rather than on the basis of the amount of work carried out. Although the PBCs are multi-year, they are only generic contracts stipulating the extent of the road network and the unit rates for the different maintenance standards and road conditions. Maintenance procurement is carried out as periodic tendering. As a result, each year an annual agreement needs to be signed that defines the exact roads to be maintained and the standards to be achieved, as well as the contract sum for that year. This means that the whole concept behind multi-year contracts is undermined, because the actual contract sum and required inputs continue to be determined on an annual basis. The Study argues that the practice of requiring annual agreements should be ended, because it prevents the potential benefits of multi-year contracts from being achieved. Periodic maintenance is an activity that is undertaken every three to five years and is concerned with rectifying defects that are outside the scope of routine maintenance. The near total absence of allocations for periodic maintenance ends up being a very expensive—and unsustainable—approach, because rehabilitated road sections rapidly deteriorate before the rest of the network is improved.

Road Asset Management System (RAMS)

76. Road asset management is concerned with providing optimal service levels with the infrastructure itself, rather than taking only a service-focused approach. Effective road asset management is dependent on the availability of information and data—this requires the use of a comprehensive computer-based system: a Road Asset Management System (RAMS). The first effort in Armenia to implement a modern RAMS started in 2005 when the ARD created the Road Data Collection and Analysis Department (RDCAD) to manage the road network data and evaluate it at project and network levels. An inventory of 17 interstate roads (around 1,700 km) and 56 republican Roads (around 1,700 km) has been carried out by the RDCAD since 2005—it is included in the road network databank. The local lifeline roads that have been categorized as republican roads since 2009 (276 roads; around 2,300 km) are not yet included in the road network databank. No proper inventory is available for these roads—an important lacuna.

Expenditures in the Road Sector

77. Road maintenance expenditures on interstate and republican roads have remained very low in the past seven years, while rehabilitation expenditures have increased. The Government spent approximately 0.2% of GDP annually on road maintenance from 2005-2011, an average US$16 million per year. This contrasts with allocations of about 1% of GDP, which are normally seen in high-income countries with mature networks in good condition. Maintenance allocations for local and republican lifeline roads were insufficient; no funds were allocated for periodic maintenance of interstate and local roads. The community-owned local road network receives hardly any maintenance allocations, because it is funded from local revenue—which is very low.

78. As part of the Study, the World Bank has estimated the amount of spending that would be required in order to raise the percentage of interstate and republican roads in good or fair

condition. To this end, the HDM-4 Model (Box 2) has been used to measure the performance of roads managed by the ARD. The total expenditures on interstate and republican roads has been projected to reach only US$68 million by 2011. However, the HDM-4 analysis suggests that US$98 million should be invested annually in the next five years—and subsequently, US$74 million should be invested annually—in order to eliminate the rehabilitation backlog in 10 years. This would achieve a target of 65% of roads in good or fair condition by 2020.

Financing of the Road Sector

79. Additional resources will need to be found for financing the maintenance backlog. This can be addressed by improving the efficiency of resource allocation, improving the prioritization of works, and generating additional revenues. The Study presents five policy options in this regard:

80. ***Option 1: Increase Efficiency of Current Expenditures.*** Road maintenance and improvement challenges can be addressed by revising priorities and increasing implementation efficiency, through the use of RAMS. This will help: (i) to determine maintenance activities required and cost per road link; (ii) to prioritize with regard to available budget and any additional revenues; and (iii) to improve contracting efficiencies. Reducing less productive expenditures and redirecting funds to higher priority projects can help expedite the development and maintenance of important roads. Road development works—such as widening and upgrading—should be contracted out only after passing a rigorous economic evaluation, using tools such as HDM-4.

81. ***Option 2: Develop Cost-effective Design Standards for Low-traffic Roads.*** The standards used to rehabilitate local roads are higher than justified by the level of traffic. Thus, the limited financial resources wind up being allocated to the rehabilitation of a few segments of roads, which increases total transport costs without improving the overall quality of the network. The design standards should also be reviewed to allow for more cost-effective designs for roads carrying lower traffic volume. Utilizing thinner asphalt, surface dressings and slurry seals as well as gravel pavements are all options that could be considered to provide good accessibility at a lower cost.

82. ***Option 3: Increase Road-user Charges.*** Revenue could be increased by introducing additional user charges—for example, higher fuel taxes. According to a November 2010 report by the GTZ, the US price for diesel was 76 US cents per liter, and the price for super gasoline was 84 US cents per liter. In Armenia, those prices are 108 US cents per liter for gasoline, and 99 US cents for diesel. These are lower than the comparable prices in Georgia or Moldova, which have a lower GDP per capita level—which suggests that such rises, if warranted, could still pass affordability considerations.

83. ***Option 4: Earmarking.*** One option for financing road works is by earmarking, through the creation of a road fund. Armenia has plans to earmark additional resources through

legislation requiring fuel taxes (10% on petrol and 10% on diesel) to be used for routine maintenance.[34] The Study found that earmarking funds for routine and periodic maintenance on a pilot basis could provide a good 'test' of its impact assessment demonstrating that the element of entitlement is put to good use.

84. ***Option 5: Borrowing.*** Borrowing represents the more evident option for financing gaps in budget allocations. However, borrowing—whether domestic or external—implies the need to repay, and thus raises the question of whether the return on the expenditure justifies the cost. Borrowing to finance recurrent costs such a routine maintenance is unlikely to be a viable strategy, because it would quickly build up debt that would then need to be serviced—which would generate an increased interest burden on the budget. The optimal policy is to borrow for higher return capital works—such as rehabilitation, and to a certain extent periodic maintenance—rather than to borrow for new construction or improvement works.

85. ***Option 6: Mobilizing Private Sector Resources through Public-Private Partnerships (PPPs).*** At present, most forms of PPPs do not appear to be realistic mechanisms for financing roads. This reflects: (i) a low traffic volume, which increases the financial burden on either the concessionaire or the Government[35]; (ii) an inadequate legal, technical and financial capacity to prepare and implement PPP projects; (iii) tightened credit conditions and a weak investment climate; (iv) governance concerns; and (v) the absence of access-controlled roads. However, the Government could consider using PPPs for road maintenance and rehabilitation works through multi-year performance-based contracts for key interstate roads.[36] This would enable the Government to transfer the construction risk to the contractor and ensure optimum management of a section of a road or road network over a long period—up to 10 years.

Key Recommendations

86. Armenia has greatly modernized the management of its road network in recent years. For example, it has begun to contract all road works and to adopt a form of performance-based maintenance contracts. Nevertheless, there is significant room for reforms aimed at improving the effectiveness and efficiency of road management in Armenia. Toward that end, the Study makes the following recommendations:

- **Adopt Policy Option 2: Develop Cost-effective Design Standards for Low-traffic Roads.** This would involve a twofold policy approach to manage the network. For interstate and republican roads, the focus should be on maintaining existing road assets through the proper monitoring, planning and programming of maintenance and

[34] This is currently a draft proposal for approval by the Parliament.
[35] If the concessionaire was willing to assume traffic risk, low traffic volumes would mean lower revenues and potential difficulties in meeting debt service requirements. If the Government were to bear the traffic risk by agreeing to an availability payment, it would lose some of the toll revenue it had budgeted.
[36] Armenia: Private Participation in the Road Sector, World Bank Guidance Note prepared by Jukka-Pekka Strand and Vickram Cuttaree, March 2011, Washington D.C.: World Bank.

rehabilitation works. For lifeline and local roads, the focus should be on providing reliable and cost-effective access for as much of the rural population as possible, rather than on maintaining high standards for a few communities. To properly manage interstate and republican roads requires a clear role, line of accountability and responsibility for the ARD, and a strengthening of the ARD road asset management capacity. The ARD needs to perform a strategic evaluation of the network and define a target performance to be achieved sometime in the future—it also needs to secure the funding required to achieve this target.

- **Clarify the Institutional Responsibility for Maintenance of Republican Lifeline Roads.** There is a need to clearly define which institution is responsible for monitoring, management, and maintenance of lifeline roads. These roads are now classified as republican roads—this has increased the MOTC's road maintenance and rehabilitation funding responsibility. However, these roads have not yet been fully incorporated into the road inventory and annual budget of the MOTC/ARD. The ARD is a suitable entity to manage these roads, provided it receives proper funding.

- **Prioritize Periodic Maintenance Road Works.** There is a need to give priority to routine maintenance, periodic maintenance, and rehabilitation road works, because the network has become highly deteriorated. There is a need to give higher priority to periodic maintenance in order to avoid excessive routine maintenance (in particular pothole patching) when periodic maintenance makes more sense.

- **Finance the US$30 Million Gap for the HDM-4 Scenario 3.** It is recommended that the Government adopt the HDM-4 scenario 3: to eliminate the rehabilitation backlog in 10 years. That would mean a funding gap for the next five years of an estimated US$30 million as compared with current projections. The Government should revise its priorities in order to increase the efficiency of maintenance and rehabilitation expenditures. It should redirect funds to projects with high economic priority, introduce improved technology, and adopt comprehensive performance-based contracts. In Armenia, fuel excise taxes and the share of road-user revenues to GDP are lower than in other European countries. Therefore, fuel excise taxes could be an attractive instrument option to cover the funding needs for maintenance and rehabilitation works. A fuel levy of US$6 cents per liter would be needed to collect the extra US$30 million in revenues. Priority should be given to rehabilitation and periodic maintenance—which have very high economic returns—rather than to network improvement works such as new road construction.

- **Review Existing PBCs, and Expand the Scope of New PBCs.** There is a need to explore expanding the use of performance-based contracts to cover periodic maintenance and rehabilitation works in addition to routine maintenance. The preferred contract option

is multi-year PBCs that assign the responsibility to a contractor to maintain a network of roads at a defined level of service. The reasons are as follows: (i) because it secures the funding requirements for maintenance during the duration of the contract; (ii) because it avoids costs overruns; and (iii) because it yields better overall quality road works and road-user satisfaction. On the current performance-based routine maintenance contracts, annual agreements should be abolished, and procurement should be carried out in a staggered manner.

- **Strengthen the Road Asset Management System (RAMS).** There is a need to better institutionalize a RAMS within the ARS. This requires: (i) improving the processes of data collection and evaluation; (ii) ensuring that the dedicated group in charge of the system has clear obligations, proper resources, and adequate technical capacity; and (iii) procuring and maintaining proper equipment. The weakest elements of the current system are: (i) the lack of a GIS interface; (ii) the limited network data collection for Republican roads; and (iii) the limited network traffic counts program. Incorporating lifeline roads into the RAMS should be a high priority for the ARD. The local lifeline roads that have been categorized as the republican roads since 2009 (276 roads; around 2,300 km) have not yet been included in the road network database. No proper inventory is available for these roads—an important lacuna.

- **Increase the Scope of Network Monitoring.** At present, monitoring is mostly restricted to interstate roads. There is a need to annually monitor the condition, traffic and accidents on all interstate and republican roads. In order to help decision-makers with the planning and programming of road works, the ARD should systematically produce an annual report that presents monitoring indicators, maintenance and rehabilitation requirements, expected performance of the network, and the main road activities of the year.

Annex 1. Public-Private Partnerships

Public-private partnerships (PPPs) provide an alternative partnership model in-between the public and private sectors, in which a private firm provides a global service with sufficient autonomy and incentives to produce efficiency gains for the benefit of all parties—and in particular of road-users. The table below shows the responsibility matrix for conventional procurement and main PPP options—the principal characteristics of each contract type are described in the section that follows.[37]

Responsibility Matrix for Conventional Procurement and PPP Options

<table>
<tr><th rowspan="2">Category</th><th colspan="2" rowspan="2">Works and Service Contracts (conventional procurement)</th><th colspan="4">Public-Private Partnership</th><th rowspan="2">Privatization</th></tr>
<tr><th colspan="2">Management and Maintenance Contracts</th><th>Operation and Maintenance Concessions</th><th>Build Operate Transfer Concessions</th></tr>
<tr><th>Type</th><th>Design-Bid-Build</th><th>Design and Build</th><th>Management Contracts</th><th>Performance-Based Contracts</th><th>Lease or Franchise or Affermage Brownfield</th><th>BOT/DBFO/BOO Greenfield</th></tr>
<tr><td>Design</td><td>Private by fee contract</td><td rowspan="2">Private by fee contract</td><td></td><td></td><td></td><td rowspan="3">Private by concession contract</td><td rowspan="5">Private</td></tr>
<tr><td>Build</td><td>Private by fee contract</td><td></td><td></td><td></td></tr>
<tr><td>Operation and Maintenance</td><td>Public</td><td>Public</td><td>Private by fee contract</td><td>Private by BBC contract</td><td rowspan="2">Private by concession contract</td></tr>
<tr><td>Finance</td><td>Public</td><td>Public</td><td>Public</td><td>Public</td><td></td></tr>
<tr><td>Own</td><td>Public</td><td>Public</td><td>Public</td><td>Public</td><td>Public</td><td>Public after contract (BOT/DBFO) or Private (BOO)</td></tr>
<tr><td rowspan="3">Private sector revenue options</td><td></td><td></td><td></td><td></td><td colspan="3">Tolls (concession model)</td></tr>
<tr><td></td><td></td><td></td><td colspan="4">Availability payments (PFI model)</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Government guarantees and support
Other support (e.g. insurance)</td></tr>
</table>

Source: EGIS

Conventional procurement methods of design-bid-build and design and build are not currently considered within the normal range of PPP options.

[37] This annex was extracted from Toolkit for Public-Private Partnership in Roads and Highways - www.ppiaf.org/ppiaf/sites/ppiaf.org/files/documents/toolkits/highwaystoolkit/index.html. Further details can be found in the website.

Design-bid-build: A traditional project delivery approach that was used for most of the 20th century to procure public works. The design-bid-build model segregates design and construction responsibilities by awarding the former to an independent private engineer, and the latter to a separate private contractor. It also includes quantity-based maintenance contracts. The remuneration of the contractor is based on unit prices defined in the construction or maintenance contract, and quantities measured on site.

Design and Build: A project delivery method under which the owners execute a single, fixed-fee contract that covers both architectural/engineering services and construction. The design-build entity may be a single firm, a consortium, a joint venture, or another type of organization assembled for a particular project.

The design-builder assumes responsibility for the majority of the design work and all of the construction activities—together with the risks associated with providing these services for a fixed fee. Clients usually retain responsibility for financing, operating and maintaining the project. Design-build procurement has been more prevalent in the private sector, but it is also gaining acceptance among many public sector transportation infrastructure clients.

Management contract: An arrangement by which a private company is entrusted with various types of tasks—related to the organization of road maintenance operations—that are usually performed by the public authority. Management contracts can also (or only) focus on operation management. In the latter case, the tasks typically entrusted to the private sector include: (i) traffic counting; (ii) axle-load weighing and providing traffic information; (iii) traffic management, including surveillance; (iv) stand-by services for accidents; (v) traffic regulation; and (vi) toll collection (which is usually not remunerated on the basis of the amounts collected, but rather on a fixed-rate basis).

Performance-based maintenance contract (PBC): An arrangement by which a contractor is selected to maintain and/or rehabilitate a designated road section(s). Remuneration is based on a monthly fee that is determined up-front, stated in the contract, and linked to performance indicators. The client does not specify any method or material requirements, but instead specifies performance indicators that the contractor is required to meet. For example, the contractor is not paid for the number of potholes patched, but rather, for the output of the work—i.e., no pothole remaining open; or 100% of potholes patched. If the contractor fails to comply with the performance indicators or to promptly rectify revealed deficiencies, then the contractor's payment is adversely affected through a series of clearly defined penalties. In the case of compliance, the payment is regularly made—usually in equal monthly installments.

Operation and maintenance concessions (*service concessions*): An arrangement by which the client grants a concession to the private participants to operate and maintain an existing road. The private entity generally collects tolls from users—thus, the financing burden of operation and maintenance is shifted to the road–user, and in return tends to increase the efficiency of the

road's operation and maintenance. According to the Private Participation in Infrastructure (PPI) database, this type of concession is also referred to as "affermage" (French term for franchise lease), or "concession".

Operation and maintenance concessions enable the public sector to transfer commercial risk to the private sector. It creates incentives for the private sector to ensure efficient revenue collection and to undertake regular maintenance, thereby increasing the reliability of facilities and postponing their renewal.

Build-Operate-Transfer (BOT) type of concessions (*works concessions*): An arrangement under which the private sector participants typically establish a project company through which they construct, control, operate and maintain a project for a determined length of time—the concession period. The private sector participants then transfer the project company assets back to the host government after the concession period has elapsed. BOT concessions require the mobilization of private funding sources in order to draw in large investments. Those investments are repaid from the revenue collected from road-users—usually tolls. A key element of a successful BOT concession is to establish a fair risk allocation. Many variations on this type of contract have been created—with a consequently growing number of acronyms used to label them: Design-Build-Finance-Operate; Build-Own-Operate-Transfer; Build-Transfer-Operate. The PPI database also refers to this PPP type as "greenfield".

In addition, BOT concessions offer the following advantages: (i) increased value-for-money through efficiencies in construction costs and plant and labor management; freedom from public budget constraints; and (iii) rapid mobilization of investment funds through project finance non-recourse funding. However, if there is little previous experience with BOTs in the country, tendering and contracting may initially be lengthy procedures.

Privatization: The transferring of ownership of a public service or facility—sometimes together with its ancillary activities—to the private sector. Thus, it is to be managed in accordance with market forces, and within the framework of an exclusive right granted by a ministerial or parliamentary act (or sometimes a license). Because there is a full transfer of ownership in which the private sector assumes all risks and responsibilities associated with the activity, it is not generally considered a PPP.

Annex 2. Performance-based Contracts

This annex covers performance-based contracts (PBCs) that differ significantly from the method-based contracts that have traditionally been used to maintain roads in developing countries.[38] Under traditional method-based contracts, the road agency as a client normally specifies techniques, technologies, materials and quantities of materials to be used, together with the time period during which the maintenance works should be executed. The payment to the contractor is based on the amount of inputs (e.g., cubic meters of asphalt concrete, number of working hours). Under a PBC, the client does not specify any method or material requirements. Instead, the client specifies performance indicators that the contractor is required to meet when delivering maintenance services (e.g., maximum roughness, number of potholes). Thus, payments are explicitly linked to the contractor successfully meeting or exceeding these clearly defined performance indicators.

A "simple" PBC would cover a single service (e.g., only mowing, only street light maintenance) and could be awarded for relatively short periods (several months or one year). A "comprehensive" PBC would typically cover all road assets with the right-of-way, and would comprise the full range of services needed to manage and maintain the contracted road network. Such services would include routine maintenance, periodic maintenance, and traffic accident assistance. The contract tenure is usually from 3-10 years, and could go up to 30 years. Rehabilitation is not a compulsory component of a "comprehensive" PBC. Some road agencies include rehabilitation as part of the PBC; others choose to handle rehabilitation using traditional method-based approaches.

The PBC approach offers several advantages. These include: (i) cost savings in managing and maintaining road assets; (ii) greater expenditure certainty for road agencies; (iii) ability to manage the road network with fewer agency staff; (iv) better customer satisfaction; and (v) stable multi-year financing of maintenance. The PBC can lead to cost savings through:

- Incentives to the private sector for innovation and higher productivity;
- Reduction in administrative expenses and road agency overheads, due to better packaging of contracts, requiring fewer agency personnel to administer and supervise contracts; and
- Significantly greater flexibility in the private sector (vs. the public sector) to reward performance and react quickly against non-performers.

A PBC helps to ensure that variation orders are minimized and that the contractor is paid in equal monthly installments throughout the contract period. The risk for cost overruns is transferred to the contractor. The road agency faces fewer unpredictable costs; fewer contracts need to be

[38] This annex extracted from World Bank Technical Note27 "Performance-based Contracting for Preservation and Improvement of Road Assets" by Natalya Stankevich, Navaid Qureshi and Cesar Queiroz. August 2009. http://go.worldbank.org/1JAIRA9Z10

processed and administered; there is no need to measure vast quantities of inputs as a basis for payments. Due to the reduced administrative effort required, the road agency can manage its network with fewer in-house personnel. A PBC approach can help to ensure stable financing for the maintenance program over a longer term as compared with traditional method-based contracts. As PBC typically covers a period of several years—it obliges the Government to make a multi-year funding commitment for road maintenance.

The selection process in performance-based contracting is normally based on the best value—which may not necessarily be the lowest bid. More risks and management responsibilities are carried by the contractor. Therefore, the contracting agency needs to ensure that the potential contractor has: (i) strong management capacity; (ii) a clear understanding of the new approach; and (iii) the ability to handle the associated risks. Under a PBC, payments are made on a fixed-price lump sum basis—normally through uniform installments. Payment is linked to meeting performance targets—the contractor is not paid for physical works completed, but for the final results delivered. The duration of PBCs is typically longer than that of traditional contracts, because the contractor carries greater risk and responsibility, and is obliged to undertake certain maintenance interventions that occur every few years.

Use of PBCs requires the existence of a mature and well-developed contracting industry with the capability to undertake long-term management of contracted assets, assume additional risks, and establish necessary programming and quality assurance mechanisms. To be successful, PBCs need a strong partnering philosophy. This is particularly critical in the initial stages when the client and the contractor have the least experience with this approach, and when performance indicators and monitoring procedures are still evolving. Good communication is essential between the client, the contractors and the supervisor/engineer, in order to facilitate the discussion and prompt resolution of issues and concerns, and to minimize the risk of future disputes and claims.

Performance indicators should be established for each asset to be contracted out. The selection and definition of indicators should be based on: (i) road-user needs; (ii) the expectation of the client to have the completed work reach or surpass the level initially agreed upon; (iii) affordability—or the level of funding available. Only a vital limited number of performance indicators should be specified. Payment conditions should be linked to performance indicators spelled out in the contract. The contractor will be paid a fixed-price lump sum price in the case of compliance with these indicators. Periodically, penalties for non-compliance should be set for each indicator and deducted from scheduled payments. A PBC involves a significant shift in risk and management responsibilities to the contractor. Therefore, the Conditions of Contract should clearly define the new roles of the client and contractor, and should identify all potential risks and allocate these to the party that can manage them best.

Annex 3. Comparison between Traditional Contracting and Output- and Performance-based Road Contracts in the Armenian Road Sector

Under traditional contracts for maintenance works, the contractor is responsible for the execution of works that are normally defined by the road agency—in this case, the Armenian Road Directorate (ARD)—and the contractor is paid on the basis of unit prices for different work items (i.e., a contract based on "inputs" to the works). This modality often brings improvement over force-account maintenance practices. Nevertheless, the results are, in many cases, still less-than-optimal. The problem is that the contractor has the wrong incentive—which is to carry out the maximum amount of works—in order to maximize its turnover and profits. Under this modality, it has been observed that even if a lot of work is carried out and much money is spent, the overall service quality for the road-user is dependent on the quality of the design given to the contractor by a separate party—and as a consequence, the results are sometimes not satisfactory.

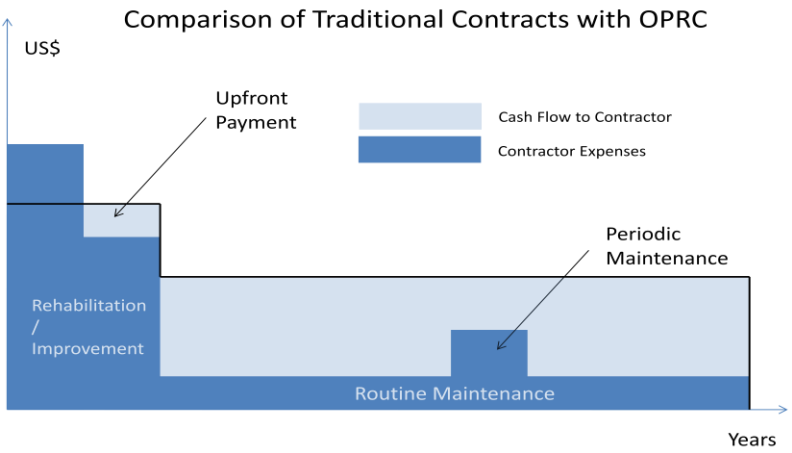
The OPRC tries to address the issue of inadequate incentives. During the bidding process, contractors compete among each other by proposing a fixed monthly lump sum fee per km of road serviced. Contractors are not paid directly for "inputs" or physical works (which they will undoubtedly have to carry out), but for "outputs". The latter include: (i) the initial rehabilitation of the road to pre-defined standards (if so required by the bidding documents); (ii) the maintenance service of ensuring certain quality levels on the roads under contract, and specific improvements (if so required by the bidding documents). The monthly lump sum remuneration paid to the contractor covers all physical and non-physical maintenance services provided by the contractor—except for unforeseen emergency works, which would be remunerated separately. The initial rehabilitation works that were explicitly specified by the Employer in the contract would be quoted on the basis of measurable output quantities, and paid as performed. In order to be entitled to the monthly payment for maintenance services, the contractor must ensure that the roads under contract comply with the service-quality levels that were specified in the bidding document. It is possible that during some months the contractor will have to carry out a rather large amount of physical works in order to comply with the required service levels; and that during other months very little work will be required. Nevertheless, the monthly payment remains the same as long as the required service levels are met.

The contractor is responsible for designing, scheduling, and carrying out the actions required to comply with the service-quality levels stated in the contract. The service-quality levels are defined from a road-user's perspective, and may include factors such as average travel speeds, riding comfort, safety features, etc. If the service-quality is not achieved in any given month, the payment for that month may be reduced or even suspended. Under the OPRC, the contractor has a strong financial incentive to be efficient. In order to maximize profits, he must reduce his activities to the smallest possible volume of intelligently designed interventions, which

nevertheless ensure that pre-defined outputs (measured indicators of service level) are achieved and maintained over the course of time.

The OPRC makes it necessary for the contactor to have a good management capacity. Here, "management" means the capability to define, optimize and carry out in a timely basis the physical interventions that are needed in the short, medium and long term, in order to guarantee that the roads remain at or above the agreed upon service-quality levels. In other words, within the contract limitations and within compliance with local legislation, technical and performance specifications, and environmental and social regulations, the contractor is entitled to independently define: (i) what to do; (ii) where to do it; (iii) how to do it; and (iv) when to do it. The role of the employer is to enforce the contract by verifying whether the agreed upon service levels—as well as the requirements laid out in all other legislation and regulations—have been met..

As compared with traditional contracts, OPRCs create a different flow of funds between the public and the private sector. The figure below depicts this difference. With an OPRC, the contractor is required to ensure that the road section meets a given performance standard—and may have to improve or rehabilitate certain sections of the road. Then, the contractor is responsible for the maintenance—for ensuring that the road section remains at that quality level. The payment from the Government does not match the expenses on a year-by-year basis—the profile must provide the contractor sufficient incentives to stay on until the end of the contract and to maintain the road at the expected standards. When the amount of rehabilitation/improvement at the beginning of the contract is high—or if the contractor is unlikely to obtain long-term and inexpensive financing—an upfront payment can be made. However, it should not be so high as to remove the incentive to perform.



Annex 4. Review of International Experience with OPRCs

The World Bank has had a highly positive experience with this approach in Brazil with the execution of CREMA—*contratos de reabilitacao e manutencao* (rehabilitation and maintenance contracts).[39] Some of the basic principles underlying Brazil's CREMA include:

(a) Bundling rehabilitation and maintenance in contracts of up to 5 years. Rehabilitation works and maintenance services are bundled together under one contract, with rehabilitation works for 3-4 years, and with maintenance services undertaken throughout the contract period. With contractors accountable for maintenance, there are incentives to execute rehabilitation works in a timely fashion and to deliver high quality service, in order to keep maintenance costs down.

(b) Use of performance indicators for rehabilitation and maintenance. Contractors are accountable for the road condition. Payments are linked to performance, as measured by specifically designed indicators, for both rehabilitation and maintenance.

(c) Standard bidding documents prepared for rehabilitation and maintenance service contracts. The road administrations did not have standard bidding documents. Therefore, regularly providing the road administrations with those documents reduced time in preparing and reviewing contract documentation.

(d) Rehabilitation and maintenance OPRCs for large road sections. The traditional input-based contract approach typically includes 80 km for rehabilitation and 130 km for maintenance. By contrast, CREMA's rehabilitation and maintenance OPRCs are for road sections of 450-600 km. Such large contracts increase construction industry interest.

(e) Contracts tendered on quality-detailed engineering designs. These designs are standardized and simplified on the basis of strengthened technical solutions.

The experience with OPRCs in Brazil has been very successful in terms of costs, road condition, and impact on the executing agency's workload.[40] For example, the evidence suggests that CREMA rehabilitation unit costs of works were 25-35% lower than traditional rehabilitation costs for contracts signed during the same period (2000-2005); and CREMA

[39] Eric Lancelot (2010), *Performance Based Contracts in the Road Sector: Towards Improved Efficiency in the Management of Maintenance and Rehabilitation*. Transport Papers TP-31, March 2010, Washington, DC: World Bank Group.

[40] Eric Lancelot (2010), *Performance Based Contracts in the Road Sector: Towards Improved Efficiency in the Management of Maintenance and Rehabilitation*. Transport Papers TP-31, March 2010, Washington, DC: World Bank Group.

maintenance unit costs of works were 34% lower than traditional maintenance unit costs. The lower costs reflected a number of factors including: (i) a lower number of addenda to contracts; (ii) the use of lighter solutions; and (iii) a greater focus on preventive rather than curative actions. The agency's workload has been reduced, because larger contracts were bid and contract duration was lengthened, thereby decreasing the administrative burden. Supervision of works was made easier, because monitoring performance and auditing contractors' quality assurance processes is less time consuming than verifying detailed quantities and inputs as per bills of quantities. The OPRC experience in Brazil allowed contractors to: (i) customize interventions and optimize rehabilitation works; (ii) shift focus from curative to less expensive preventive interventions; (iii) decrease the administrative burden on the road agencies; and (iv) provide overall better results to road-users at lower costs.

Box 6: Argentina's Experience with CREMA; Second Phase

The second phase of CREMAs in Argentina aimed at rehabilitating and maintaining 8,200 km of the paved non-concessioned national network that had not been included in the first phase, at a total cost of about US$550 million. The most significant differences between the first and second generation of CREMAs can be summarized as follows:

- The network under consideration for the second phase is in somewhat worse condition than the network of CREMA 1. The average roughness of the phase I network was about 3.6 IRI before implementation of the CREMA, with about 40% of its length in critical to poor condition; the average roughness of the phase II network was nearly 4 IRI before work execution, with about 50% of its length in critical to poor condition. Because of that, the proportion of roads to be rehabilitated in the near future has increased to about 65-70%—much higher than the 40% indicated above for the CREMA phase 1;

- The rehabilitation solutions used for the second generation of CREMAs is much closer to the optimum strategy recommended by the HDM-4 model, corresponding to an average thickness of asphalt overlay of about 5 cm, with a higher unit cost per km—nearly US$150,000 per year;

- The period during which rehabilitation works are to be executed has been increased from 12 to 18 months—and in certain cases, to 24 months;

- The payment mechanism has been changed. The contractors now receive full payment for the rehabilitation works as they proceed during the first 18-24 months; and adjustments for inflation are made on a monthly basis throughout the contract period;

- The scope of mandatory works to be executed—in addition to the overlay operations—has been increased. The objective is to improve road safety conditions, by including in the contract such requirements as mandatory horizontal marking, improvements at critical intersections, and enhancement of guardrail features;

- The damage to roads caused by vehicle overloading is being more aggressively addressed, by asking contractors to provide and operate devices for measuring axle loads on site, and to report any excess load problems to the highway authority.

Argentina has had 15 years of experience with CREMA projects—and there are similarities to the Brazil experience. However, in Argentina the rehabilitation works were carried out during the first 12 months, and the maintenance activities covered the 5-year contract period. Payments consisted of 5% of total costs as an advance, 20% after the first six months, 20% after the first 12-month rehabilitation period, and the remainder in equal amounts per year. With the rehabilitation works concentrated into the first 12 months (unlike in Brazil), there is a reduced burden on contractors to obtain financing of one year or more from commercial banks to pre-finance the works. In Argentina—echoing the Brazilian experience—the winning bidder carried out the final engineering design.

For CREMA 1 in Argentina, 60 sets of bidding documents were prepared that covered 11,500 km of paved roads—implementation occurred during the period of 1997-2002. Over the course of time, CREMA has undergone adjustments both in terms of procurement and design. On the procurement side, there have been modifications in the size of the bid package and in the change to payment modality. This includes changes in: (i) the nature of rehabilitation works; (ii) the specific amount allocated to maintenance; (iii) price adjustments; and (iv) advance payments. On the design side, there have been increases in: (i) overlay thickness; (ii) the specific amount allocated to maintenance; (iii) price adjustments; and (iv) advance payments (Box 5).

In February 2008, the Bank approved a US$333 million equivalent credit for Nigeria, the Federal Roads Development Project (P090135). This included investments on 670 km of federal roads—with contracts to be awarded in five lots, using OPRCs for rehabilitation, upgrading, and maintenance. The institutional strengthening and policy reform component of the project aimed to create, among other things, an enabling environment for long-term OPRCs. In a letter to the World Bank dated June 2010, the Nigerian Road Sector Development Team (RSDT) noted that OPRC was not the right approach for the selected roads, because the rehabilitation part of the contract exceeded 80% of the estimated contract value—reflecting the initial poor condition of roads.[41] For one lot, none of the eight pre-qualifying bidders submitted a bid, due to the state of the roads—and the accompanying risks—and the need for a great deal of pre-financing, which they could not afford.

The new strategy proposed by the RSDT was to use the traditional FIDIC contract and ICB procurement process for the initial rehabilitation works, and then to switch to the OPRC for the long-term maintenance services. The initial rehabilitation would take the roads to a level at which they would be suitable candidates for the subsequent OPRC long-term maintenance. One year of free maintenance would also be gained during the defects-liability period, because the responsibilities of the rehabilitation contractor would include maintenance of the road for one

[41] When initial rehabilitation costs exceed 40% of the total contract cost, rehabilitating roads through a traditional contract is more advisable. Natalya Stankevich, Nvaid Qureshi, and Cesar Queiroz (2009), *Performance-based Contracting for Preservation and Improvement of Road Assets*. Transport Note No. TN-27. World Bank, Washington, DC, pp. 7-8.

year. In a letter dated November 26, 2010, the Federal Ministry of Finance of Nigeria wrote to the World Bank requesting a project restructuring that entailed the elimination of the "unpopular contracting concept of Output and Performance-based Road Contracts". This letter confirmed the RSDT's request to reintroduce traditional road contracting for rehabilitation and to maintain OPRCs for maintenance. The Nigerian experience highlights the factors that must be addressed in order to create successful OPRCs: (i) the condition of roads selected for rehabilitation; (ii) the share of rehabilitation works in total contract value; (iii) the issue of pre-financing rehabilitation works, and the availability of financing; and (iv) the risk appetite of contractors. The absence of an adequate and in-depth assessment by an experienced international consulting firm prior to the preparation of the bidding documents was one of the key reasons for the lack of success in Nigeria.

In contrast to Nigeria, Zambia has had a positive experience with the introduction of OPRCs. The Rural Roads Improvement Facility aimed to improve roads in five districts. The selected unpaved roads were to be improved and maintained over a period of five years in order to provide all season access at predefined service levels. All five contracts were signed in 2008. The Road Development Agency (RDA) has calculated that the OPRC methodology has brought about a savings of about 30% over conventional contracting costs. The Bank-financed OPRCs benefited from some of the lessons learned from EU-funded OPRCs—in particular, the negative impact of: (i) little or no surveys conducted prior to preparation of the bidding documents; (ii) lack of precision of bidding documents, which created confusion concerning the scope of works; (iii) wide dispersion of roads in a package, resulting in inefficiencies; (iv) no limit with regard to the proportion of the cost of rehabilitation and maintenance—which in some cases led to 95% of the contract sum being paid during the first nine months of the contract, thereby reducing the incentives of contractors for the remainder of contract duration; and (v) using travel speeds rather than defects of the road surface as key performance specifications—which allowed poor quality roads to meet the requirements.[42]

Some of the key characteristics of the Bank-funded OPRC contracts under the Rural Roads Improvement Facility included the following: (i) front-loading of contracts was kept to a minimum by setting a limit on the proportion of works paid under unit rates during the early months of the contract; (ii) performance specifications were adapted that better reflected road characteristics; (iii) contractor/consultant partnerships were fostered; (iv) bidders were required to demonstrate access to essential management skills—and encouraged to join forces with expert consultants; (v) large contractors were encouraged to sub-contract, especially for maintenance; and (vi) consultants carried out detailed surveys on all roads assigned, following the initial condition survey. The success of the Zambia OPRC experience—in contrast to the Nigerian

[42] BCEOM *Société Française d'ingénierie*, Consultancy Services for Output and Performance-based Contracts for Unpaved District and Rural Roads in Lundazi, Katete, Chipata, Chongw and Choma Districts. Final Technical Report, December 2007.

experience—was based in part on the detailed assessment made in order to tailor the OPRCs to the characteristics of the roads and to the contracting industry, while ensuring an adequate level of risk sharing and incentives.

It is often argued that OPRCs present an important challenge to road agencies in terms of supervising works. However, traditional contracts present their own problems: supervising is often difficult because the detailed designs used are often outdated, or the geotechnical data provided to the designers is incorrect. It is possible to design OPRCs so that the contractor and the design consultant are defined as a single contracting entity, and the risk is placed on the thus defined contracting entity to design and implement the project based on the given service levels specified in the contract. A key to the success of this approach is to have a qualified and experienced monitoring supervisor, who is knowledgeable about OPRC contracts and can advise the road agency.

The projects in Liberia and Armenia both propose a contract length of 10 years. The length of the contract proposed reflects underlying asset management principles and the level of pavement deterioration. Such long-term contracts reduce the number of transactions and the costs of numerous mobilization and demobilizations that are associated with traditional shorter contracts. The Liberia Road Asset Management Project proposes a project implementation of 10 years, with the Bank project implementation period matching the contract duration. This is a project length that exceeds the Bank norms when it comes to investment projects.

Annex 5. Success Factors for Road Asset Management Systems

A Road Asset Management System is defined here as any system that is used to store and process road and/or bridge inventory, conditions, traffic and related data, for road planning and programming. The major functions of the road management process can be categorized as: (i) Planning; (i) Programming; (iii) Preparation; and (iv) Operations. A RAMS is concerned with road monitoring, planning and programming. Major activities include:

- Needs Assessment;
- Strategic Planning, including budgeting for development and asset preservation;
- Development—under budget constraints—of multi-year works expenditure programs;
- Collection of Data; all of the above activities require data—major data items include road inventory, conditions, traffic, and economic data.

What makes a RAMS successful? In addition to funding, there are three key factors: (i) processes; (ii) people; and (iii) technology. If any of these are weak or fail, then the RAMS will be compromised. Some agencies successfully consider all three factors, but many do not. The focus of too many projects is on the technology element—with insufficient attention given to the institutionalization of the system and the necessary support systems. Thus, the major cause of failure in the implementation is poor institutionalization (processes and people) rather than inadequate use of technology. It is essential to ensure that proper attention is given to institutionalization, at the very highest level.

Processes

The introduction of a RAMS by itself is not a guarantee that it will actually 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. If the agency's higher management does not recognize the value of the RAMS, they will not provide the necessary support and funding to maintain the system. Therefore, it is important to incorporate the following:

- Business Plans that utilize 'Asset Value' and other Key Performance Indicators derived from the RAMS. This is an executive and managerial responsibility. It also helps put focus on the RAMS itself, and improves the chances that budget and funds are available to run the system;
- Institutional support that consists of high ranking decision-makers fully committed to the asset management/asset preservation 'philosophy'
- Regular briefings to ministers and other high government officials on the importance of asset preservation, and on the steps that are being taken to ensure that the maintenance and rehabilitation of the road infrastructure is dealt with in a satisfactory fashion;

- Specific and realistic key performance indicators and targets to measure and preserve/enhance asset value. It is important to monitor those targets, and to make an assessment at the end of each year as to whether they have been achieved—and, if not, to take appropriate action. By publishing this information in Annual Reports, the agency is made accountable.
- Annual budgets in place for data collection and operation of the RAMS. Even if this initially requires donor-funding support, there should be a phased increase in local budgeting to ensure that the RAMS becomes self-funding within a given timeframe;
- Policies and procedures in place for data collection, and for quality assurance of that data.

People

A RAMS should be driven by a dedicated group within the agency—probably in the planning division or equivalent. This group should actively seek to promote the system within the agency—including to higher level management. This group should be tasked with: (i) raising awareness of the system; (ii) managing data collection—constantly look for ways of improving data collection procedures and data quality assurance; (iii) researching off-the-shelf packages and systems on the market; (iv) creating and maintaining technical and functional requirements for planning and programming systems; and (v) coordinating all efforts related to the RAMS in terms of other applications. The following steps should be taken in order to build an appropriate staff environment:

- There should be an organizational unit established with specific responsibility for the RAMS;
- 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 any necessary re-training. This should potentially include Master's or other post-graduate degrees that would increase the attractiveness of working in this area.

Technology

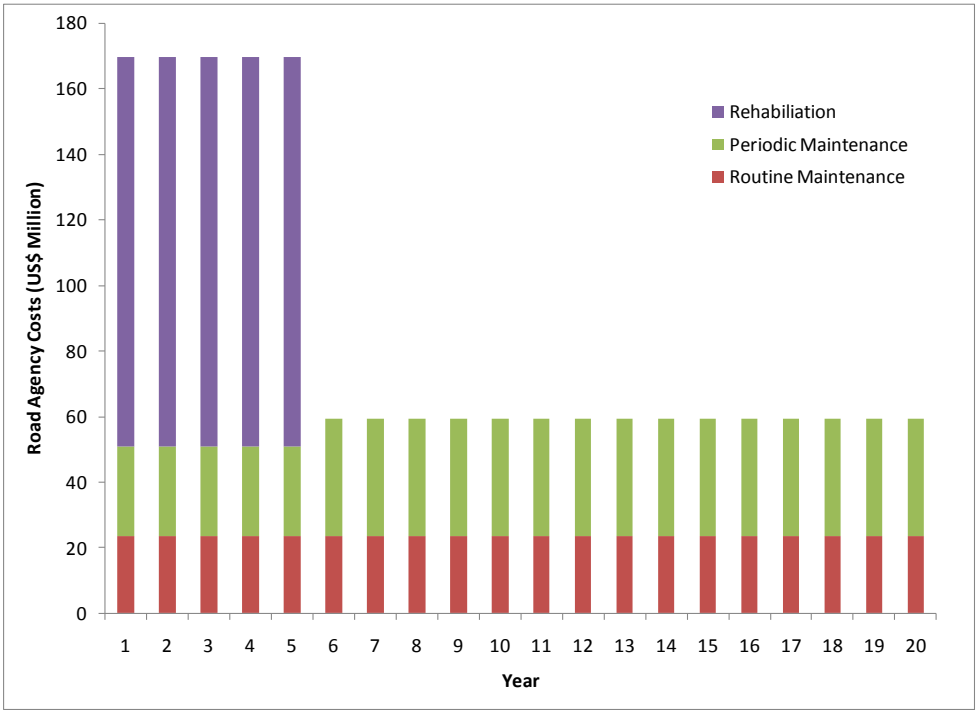
The Information Technology (IT) requirements of RAMS are demanding. The RAMS implementation should fit within the overall IT strategy of the agency, and should be properly supported from an IT perspective. Agencies should develop and adhere to a long-term IT budget strategy that includes hardware replacement strategies and the costs of hardware and software maintenance agreements.

Annex 6. HDM-4 Scenarios for Addressing the Interstate and Republican Road Rehabilitation Backlog

Option 1: Minimize Total Transport Costs Scenario

This scenario selects the maintenance standard per road class that minimizes the present value sum of road agency costs plus road-user costs over the evaluation period (total transportation costs). It is thus the optimal scenario from an economic point of view. The total rehabilitation backlog is estimated to be US$849 million. Thus, the estimates under scenario 1 suggest that in order to improve the overall condition of the road network, the Armenian Road Directorate would need to invest a total of US$170 million per year for the next five years—the recommended breakdown would be US$119 million for rehabilitation, US$17 million for periodic maintenance and US$24 million for routine maintenance. Assuming that the country meets its maintenance and rehabilitation requirements for the first five years—and clears most of the rehabilitation backlog, the total expenditures from years 6-20 would fall to US$59 million per year—and the recommended breakdown would be US$35 million for periodic maintenance, and US$24 million for routine maintenance works. The present value—at 12% discount rate—of this expenditure profile corresponds to US$920 million. This scenario achieves a target of attaining 72% of main roads in good or fair condition by 2020. Figure 9 presents this scenario. This option would require a substantial rehabilitation program during the next five years. It is highly unlikely that this option could actually be implemented by the Armenian Road Directorate, because it would entail rehabilitation and rehabilitation contracts on about 770 km of roads every year for five years.

Figure 9. Option 1: Minimize Total Transport Costs: Annual Road Expenditures from Years 1-20 (US$ millions)



Source: World Bank.

Option 2: Expenditures of US$110 Million per Year Scenario

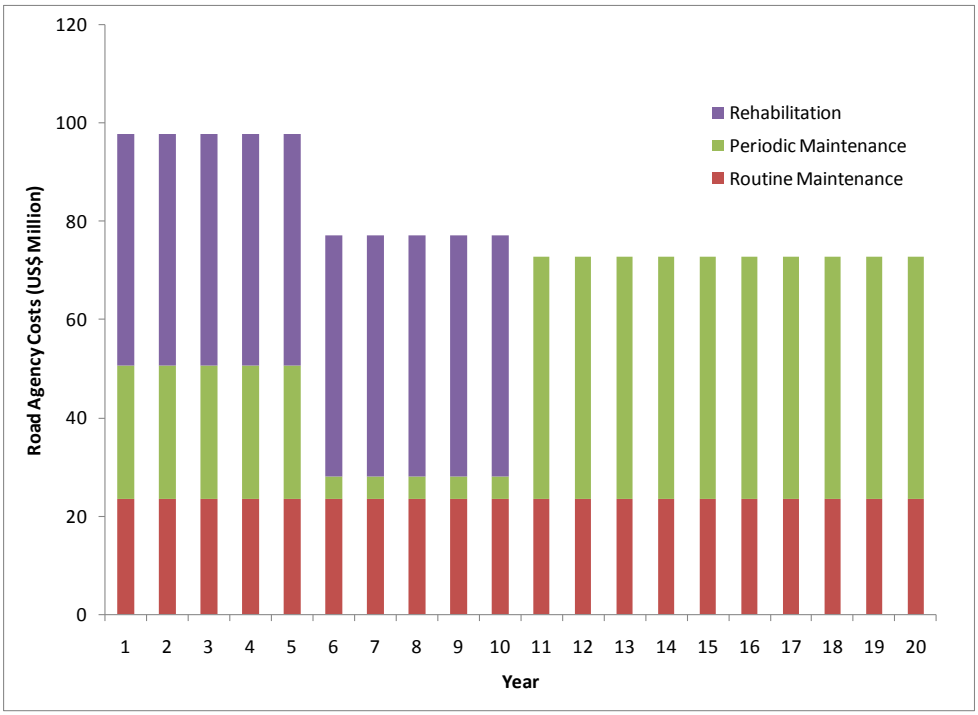
This scenario utilizes the expenditures by the Armenian Road Directorate for 2009 for road maintenance and rehabilitation for interstate and republican roads. If the Armenian Road Directorate were to invest a total of US$110 million per year for the next five years, the recommended breakdown would be US$60 million for rehabilitation, US$26 million for periodic maintenance and US$24 million for routine maintenance. The total expenditures required for years 6-20 would fall to US$73 million per year—and the recommended breakdown would be US$13 million for rehabilitation, US$36 million for periodic maintenance, and US$24 million for routine maintenance works. The present value—at 12% discount rate—of this expenditure profile corresponds to US$799 million. This scenario achieves a target of 67% of roads in good or fair condition by 2020.

Option 3: Eliminate Rehabilitation Backlog in 10 Years Scenario

Armenia will probably not be able to finance the maintenance and rehabilitation of interstate and republican roads along the lines of option 1, despite high economic benefits. Therefore, a budget-constrained scenario was devised that would eliminate the rehabilitation backlog in 10 years. The estimates under scenario 3 suggest that the Armenian Road Directorate would need to invest a total of US$98 million per year for the first five years—the recommended breakdown would be US$47 million for rehabilitation, US$27 million for periodic maintenance and US$24 million for routine maintenance. Assuming that the country meets its requirements for the first five years,

the total expenditures from years 6-20 would fall to US$74 million—and the recommended breakdown would be US$16 million for rehabilitation, US$34 million for periodic maintenance, and US$24 million for routine maintenance. The present value—at 12% discount rate—of this expenditure profile corresponds to US$ 728 million. This scenario achieves a target of attaining 65% of roads in good or fair condition by 2020. Figure 10 presents this scenario.

Figure 10. Option 2: Eliminate Rehabilitation Backlog in 10 Years: Annual Road Expenditures from Years 1-20 (US$ millions)



Source: World Bank estimates.

Option 4: Keep Current Condition Scenario

This scenario takes into consideration the current condition of the network and assumes that this condition will be maintained in the future. The estimates suggest that in order to maintain the current road condition, the Armenian Road Directorate would need to invest a total of US$82 million per year for the next five years—the recommended breakdown would be US$49 million for rehabilitation, US$9 million for periodic maintenance, and US$24 million for routine maintenance. The total expenditures from years 6-20 would fall to US$62 million per year—and the recommended breakdown would be US$13 million for rehabilitation, US$25 million for periodic maintenance, and US$24 million for routine maintenance works. The present value—at a 12% discount rate—of this expenditure profile corresponds to US$ 658 million. Under this scenario, 50% of roads would be in good or fair condition in 2020.

Annex 7. HDM-4 Road Maintenance Works Economic Evaluation

The HDM-4 Model

The Highway Development and Management (HDM-4) Model was employed to evaluate the economic benefits of road maintenance and rehabilitation works on the South Caucasus. The model estimates over a given evaluation period, for a series of user-defined road agency standards, the pavement deterioration that is a function of: (i) the road geometry, age and condition; (ii) the daily traffic and projected traffic growth rate; (iii) the climate; and (iv) the loading of trucks. The pavement condition is measured in terms of: (i) pavement strength (e.g., deflections); (ii) pavement surface distress (e.g., area of cracking and potholes); and (iii) pavement deformations (e.g., rutting and roughness). For an economic evaluation, the pavement condition is best represented by the longitudinal deformation of a road—which affects vehicle speeds, user's comfort and road-user costs. For each year of the evaluation period, the model estimates the road agency costs (rehabilitation, periodic maintenance and recurrent maintenance costs), and the road-user costs (vehicle operating and passenger time costs). The sum of the road agency and road-user costs represent the total transport costs. The objective of the evaluation is to compare the total agency costs and total transport costs of the series of road agency standards in present value terms, because this is needed to assess the timing of costs and the opportunity cost of capital in the country—which is represented by the discount rate. Without generated traffic, the recommended road agency standard is the one that minimizes the present value of total transport costs.

Primary Road Works Economic Evaluation

The evaluation considered a 20-year evaluation period—with a 12% discount rate and a 4% annual traffic growth rate. Four asphalt concrete roads were evaluated. Each carried approximately 3,000 vehicles per day (AADT). Each had different road conditions: one good; one fair; one poor; and one very poor. For all roads, the Do Minimum standard corresponds to not performing any annual recurrent maintenance works (e.g., patching, crack sealing, drainage maintenance, shoulder repair) over the evaluation period, and reconstructing the road when it reaches an extremely poor condition—with roughness equal to 16.0 IRI, m/km. The other standards evaluated per road class are as follows:

- For the road in good condition, five periodic maintenance standards were evaluated comprised of applying a 50 mm overlay triggered at 3.5, 4.0, 4.5, 5.0 or 5.5 IRI, m/km—all including annual recurrent maintenance works over the evaluation period.
- For the road in fair condition, three periodic maintenance standards were evaluated comprised of applying a 50 mm overlay triggered at 4.5, 5.0 or 5.5 IRI, m/km—all including annual recurrent maintenance works over the evaluation period. Another standard comprised reconstructing the road when it reaches 8.0 IRI, m/km—including

annual recurrent maintenance works over the evaluation period. The last standard represented performing only recurrent maintenance over the evaluation period.

- For the road in poor condition, four reconstruction standards were evaluated that were triggered at 8.0, 10.0, 12.0 and 16.0 IRI, m/km—all including annual recurrent maintenance works.
- For the road in very poor condition, two reconstruction standards were evaluated that were triggered at 12.0 and 16.0 IRI, m/km—all including annual recurrent maintenance works.

The following table presents the representative unit costs of road works adopted on the evaluation, based on South Caucasus average costs. Economic costs are 80% of financial costs.

Road Works Unit Costs				
Road Work Class	Road Work Type	Units	Financial	Economic
Recurrent Maintenance	Routine Maintenance Primary	US$/km-year	3,000	2,400
	Routine Maintenance Local	US$/km-year	1,000	800
	Patching	US$/m2	17.9	14.3
	Crack Sealing	US$/m2	6.0	4.8
Periodic Maintenance	50 mm Overlay	US$/m2	17.9	14.3
Rehabilitation	Reconstruction AC Road	US$/m2	55.0	44.0
	Reconstruction ST Road	U$/m2	40.0	32.0

The following table presents the representative economic unit road-user costs (vehicle operating costs plus passenger time costs) for different roughness levels, based on South Caucasus average vehicle fleet characteristics, and the average traffic composition. A road in fair condition (6 IRI, m/km) has road-user costs 7% higher than a road in good condition (2 IRI, m/km), whereas a road in poor condition (10 IRI, m/km), has road-user costs 24% higher, and a road in very poor condition (14 IRI, m/km) has road-user costs 49% higher.

Unit Road-user Costs Sensitivity to Roughness (US$/vehicle-km)									
Condition	Roughness (IRI,	Medium Car	Delivery Vehicle	Light Truck	Medium Truck	Heavy Truck	Articulated Truck	Small Bus	Medium Bus
Good	2	0.28	0.28	0.29	0.43	0.67	0.98	0.53	1.21
Fair	4	0.28	0.29	0.30	0.45	0.71	1.03	0.54	1.25
Fair	6	0.29	0.30	0.33	0.48	0.76	1.06	0.58	1.35
Poor	8	0.30	0.32	0.35	0.51	0.79	1.09	0.65	1.53
Poor	10	0.33	0.35	0.37	0.55	0.84	1.17	0.74	1.77
Very	12	0.36	0.39	0.41	0.59	0.91	1.27	0.84	2.04
Very	14	0.39	0.42	0.44	0.64	0.99	1.37	0.95	2.32
Very	16	0.43	0.46	0.48	0.69	1.07	1.48	1.06	2.61
Traffic Composition		60	20	3	5	5	2	2	3

The following table presents the economic evaluation results in terms of present value of road agency costs, road-user costs, total transport costs, the reduction of total transport costs compared with the Do Minimum standard (Net Benefits or NPV), in US$000 per km, and the NPV per present value of road agency costs ratio. The standard that minimizes total transport costs is considered the optimal alternative from an economic evaluation point of view. With traffic of 3,000 vehicles per day, the present value of road-user costs represents on average 98% of total transport costs. The NPV per Agency Costs ratio for roads in good and fair condition (3.0 and 2.8 respectively) is higher than for the roads in poor or very poor condition (1.3 and 1.9 respectively). This indicates that road works for roads in good and fair condition should have higher priority than road works for roads in poor or very poor condition.

Primary Road Present Values (US$000 per Kilometer) and NPV/Agency Ratio						
Road Class	Maintenance Standard	Agency	Road	Total	NPV	NPV/Agency
Good Condition	Reconstruction at 16.0 IRI, m/km	88.5	4796.4	4884.9	0.0	0.0
	RM + 50 mm Overlay at 3.5 IRI,	105.5	4592.4	4697.9	187.0	1.8
	RM + 50 mm Overlay at 4.0 IRI,	69.1	4610.8	4679.9	205.1	3.0
	RM + 50 mm Overlay at 4.5 IRI,	60.7	4623.5	4684.3	200.7	3.3
	RM + 50 mm Overlay at 5.0 IRI,	51.5	4645.6	4697.1	187.8	3.6
	RM + 50 mm Overlay at 5.5 IRI,	46.9	4661.6	4708.5	176.5	3.8
	RM	27.7	4700.3	4728.0	156.9	5.7
Fair Condition	Reconstruction at 16.0 IRI, m/km	124.4	4908.7	5033.1	0.0	0.0
	RM + 50 mm Overlay at 4.5 IRI,	135.0	4614.2	4749.2	283.9	2.1
	RM + 50 mm Overlay at 5.0 IRI,	102.8	4641.9	4744.8	288.3	2.8
	RM + 50 mm Overlay at 5.5 IRI,	88.5	4669.5	4758.0	275.1	3.1
	RM + Reconstruction at 8.0 IRI,	92.0	4826.4	4918.4	114.7	1.2
	RM	30.2	4927.0	4957.2	75.8	2.5
Poor Condition	Reconstruction at 16.0 IRI, m/km	139.3	5253.5	5392.8	0.0	0.0
	RM + Reconstruction at 8.0 IRI,	330.0	4643.9	4973.9	418.9	1.3
	RM + Reconstruction at 10.0 IRI,	201.0	4922.7	5123.7	269.1	1.3
	RM + Reconstruction at 12.0 IRI,	127.9	5248.1	5376.0	16.8	0.1
	RM + Reconstruction at 16.0 IRI,	71.2	5787.3	5858.5	-	-6.5
Very Poor Condition	Reconstruction at 16.0 IRI, m/km	174.8	5530.2	5705.0	0.0	0.0
	RM + Reconstruction at 12.0 IRI,	330.0	4739.7	5069.7	635.3	1.9
	RM + Reconstruction at 16.0 IRI,	139.3	6015.2	6154.5	-	-3.2

NPV = Net benefits compared with Do Minimum standard

RM = Recurrent maintenance

For roads in good condition, the standard of executing recurrent maintenance and 50 mm overlays when the roughness reaches 4.0 IRI, m/km yields the lowest total transport costs; thus, 4.0 IRI, m/km, is the optimal maximum roughness threshold for periodic maintenance for this level of traffic and road condition. To execute only recurrent maintenance has positive net

benefits (NPV) of US$157 thousand per km , but the net benefits are 23% lower than the standard that executes the 50 mm overlay at 4.0 IRI, m/km (US$ 205 thousand per km). Thus, a policy of executing periodic and recurrent maintenance works is preferred to a policy of executing only recurrent maintenance works or a policy of reconstructing the road when it reaches poor condition.

For the road in fair condition, the standard of executing recurrent maintenance and 50 mm overlays when the roughness reaches 5.0 IRI, m/km yields the lowest total transport costs; thus, 5.0 IRI, m/km, is the optimal maximum roughness threshold for periodic maintenance for this level of traffic and road condition. To execute only recurrent maintenance over the evaluation period has positive net benefits, but they are 74% lower than the standard that executes the 50 mm overlay at 5.0 IRI, m/km. Thus, a policy of executing periodic and recurrent maintenance works is preferred to a policy of executing only recurrent maintenance works or a policy of reconstructing the road when it reaches poor condition.

For the road in poor condition, the standard of executing recurrent maintenance and reconstruction when the roughness reaches 8.0 IRI, m/km yields the lowest total transport costs; thus, 8.0 IRI, m/km, is the optimal roughness threshold for reconstruction for this level of traffic and road condition. The standard that executes recurrent maintenance over the evaluation period and reconstructs at 16 IRI, m/km, has negative net benefits—with the present value of total transport costs higher than performing the Do Minimum standard. Thus, a policy of executing immediate reconstruction followed by recurrent maintenance works is preferred to a policy of postponing the reconstruction.

For the road in very poor condition, the standard of reconstructing the road and executing recurrent maintenance afterwards yields the lowest total transport costs. To execute only recurrent maintenance over the evaluation period and reconstruct at 16 IRI, m/km, has negative net benefits (NPV). Thus, a policy of executing immediate reconstruction, followed by recurrent maintenance works is preferred to a policy of postponing the reconstruction.

Local Road Works Economic Evaluation

Adopting the same assumptions for the primary road, four surface treatment roads were evaluated that each carries approximately 500 vehicles per day (AADT). Each had different road conditions: one good; one fair; one poor; and one very poor For all roads, the Do Minimum standard corresponds to not performing any annual recurrent maintenance works over the evaluation period, and to reconstructing the road when it reaches a extremely poor condition with roughness equal to 16.0 IRI, m/km. The other standards evaluated per road class are as follows:

- For the road in good condition, five periodic maintenance standards were evaluated comprised of applying a 50 mm overlay triggered at 4.5, 5.0, 5.5, 6.0 or 6.5 IRI, m/km—all including annual recurrent maintenance works over the evaluation period. The last standard represents performing only recurrent maintenance over the evaluation period.

- For the road in Fair condition, three periodic maintenance standards were evaluated comprised of applying a 50 mm overlay triggered at 5.5, 6.0 or 6.5 IRI, m/km—all including annual recurrent maintenance works over the evaluation period. Another standard comprised reconstructing the road when it reaches 8.0 IRI, m/km—including annual recurrent maintenance works over the evaluation period. The last standard represents performing only recurrent maintenance over the evaluation period.
- For the road in poor condition, four reconstruction standards were evaluated that were triggered at 8.0, 10.0, 12.0 and 16.0 IRI, m/km—all including annual recurrent maintenance works.
- For the road in very poor condition, two reconstruction standards were evaluated that were triggered at 12.0 and 16.0 IRI, m/km—all including annual recurrent maintenance works.

The following table presents the economic evaluation results. With traffic of 500 vehicles per day, the present value of road-user costs over the evaluation period represents on average 90% of total transport costs. The NPV per Agency Costs ratio for roads in good and fair condition (1.3 and 1.0 respectively) is higher than for the roads in poor or very poor condition (0.5 and 0.5 respectively). This indicates that periodic maintenance road works in roads in good and fair condition should have higher priority than rehabilitation works on roads in poor and very poor condition. For roads in good and fair condition, performing periodic maintenance at 5.5 IRI, m/km, and recurrent maintenance is preferred to performing only recurrent maintenance or performing recurrent maintenance and reconstruction. For roads in poor and very poor condition, performing reconstruction at 10 and 12 IRI, m/km, respectively, is preferred to postponing the reconstruction to be triggered at 16 IRI, m/km.

Local Roads Present Values (US$ 000 per Kilometer) and NPV/Agency Ratio						
Road Class	Maintenance Standard	Agency	Road	Total	NPV	NPV/Agency
Good Condition	Reconstruction at 16.0 IRI, m/km	28.0	977.3	1005.3	0.0	0.0
	RM + 50 mm Overlay at 4.5 IRI,	46.1	918.6	964.7	40.6	0.9
	RM + 50 mm Overlay at 5.0 IRI,	38.9	922.4	961.3	43.9	1.1
	RM + 50 mm Overlay at 5.5 IRI,	33.2	928.0	961.1	44.1	1.3
	RM + 50 mm Overlay at 6.0 IRI,	30.9	931.2	962.1	43.2	1.4
	RM + 50 mm Overlay at 6.5 IRI,	28.8	934.5	963.4	41.9	1.5
	RM	10.5	954.0	964.6	40.7	3.9
Fair Condition	Reconstruction at 16.0 IRI, m/km	49.3	1023.9	1073.2	0.0	0.0
	RM + 50 mm Overlay at 5.5 IRI,	70.5	932.0	1002.5	70.7	1.0
	RM + 50 mm Overlay at 6.0 IRI,	64.5	938.2	1002.7	70.4	1.1
	RM + 50 mm Overlay at 6.5 IRI,	54.4	950.7	1005.1	68.1	1.3
	RM + Reconstruction at 8.0 IRI,	67.8	969.5	1037.3	35.9	0.5
	RM	14.6	1027.4	1042.1	31.1	2.1
Poor Condition	Reconstruction at 16.0 IRI, m/km	69.2	1113.7	1182.9	0.0	0.0
	RM + Reconstruction at 8.0 IRI,	200.0	925.1	1125.2	57.7	0.3
	RM + Reconstruction at 10.0 IRI,	133.2	988.5	1121.7	61.2	0.5
	RM + Reconstruction at 12.0 IRI,	90.5	1061.4	1152.0	31.0	0.3
	RM + Reconstruction at 16.0 IRI,	47.5	1213.8	1261.3	-78.4	-1.6
Very Poor Condition	Reconstruction at 16.0 IRI, m/km	108.9	1139.7	1248.7	0.0	0.0
	RM + Reconstruction at 12.0 IRI,	199.7	947.6	1147.3	101.3	0.5
	RM + Reconstruction at 16.0 IRI,	83.3	1270.1	1353.4	-	-1.3

NPV = Net benefits compared with Do Minimum standard

RM = Recurrent maintenance

Optimal Periodic Maintenance Treatment

The following table presents a sample evaluation of the consequences of over-design and under-design of a periodic maintenance treatment represented by maintenance standards that are not appropriate for the traffic of the given road. The evaluation considers a sample road that is in fair condition (4.0 IRI, m/km) and has 3,000 vehicles per day. Four periodic maintenance standards are evaluated: (i) perform recurrent maintenance and rehabilitate the road when it is in very poor condition (16 IRI, m/km)—which is the Do Minimum scenario; (ii) perform recurrent maintenance and apply as periodic maintenance a 12 mm reseal every time the area of cracking reaches 20%; (iii) perform recurrent maintenance and apply as periodic maintenance a 50 mm overlay when the roughness reaches 5.0 IRI, m/km; and (iv) perform recurrent maintenance and apply a 80 mm overlay as periodic maintenance when the roughness reaches 5.0 IRI, m/km.

Present Values (US$000 per Kilometer)				
Road Agency Standard	Road Agency Cost	Road User Cost	Total Transport Costs	Net Benefits, (NPV) *
Reconstruction at 16.0 IRI, m/km (Do	124.4	4908.7	5033.1	0.0
RM + Reseal 12mm at 20% Cracking Area	55.6	4851.3	4906.9	126.2
RM + 50 mm Overlay at 5.0 IRI, m/km	102.8	4641.9	4744.8	288.3
RM + 80 mm Overlay at 5.0 IRI, m/km	151.3	4628.0	4779.3	253.8

* Comparison with Do Minimum scenario

The evaluation shows that the periodic maintenance standard that minimizes total transport costs is the one that applies a 50 mm overlay at 5 IRI, m/km. Applying an 80 mm overlay (over-design) or a 12 mm reseal (under-design) as periodic maintenance yields higher total transport costs over the evaluation period. Applying a 12 mm reseal reduces net benefits by 56%, and applying an 80 mm overlay reduces net benefits by 12%, compared with the optimal standard of applying a 50 mm overlay. Thus, the optimal maintenance standard for a given road (i.e., given traffic and condition) should be defined based on a life-cycle economic evaluation to minimize total transport costs or maximize society net benefits (NPV).