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The economic impact of enforcing axle load regulation – the case of Zambia

Report 0805

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Short summary:

This study is an economic assessment of regulating and enforcing axle load control of heavy vehicles in Zambia. This enforcement is part of a wider Axle Load Control Programme to prevent premature deterioration of roads and bridges, implemented in 2004 with a time frame of fours years. Among the many objectives of the programme, a new regulation pertaining to maximum permissible axle loads and gross vehicle mass (GVM) was approved in 2007 and included in the Roads Act.

Efficient enforcement of axle load regulations will have two major impacts: (1) Heavy axles (as measured by GVM) inflict an *excessive* cost in terms of wear and tear on the roads. They may cause additional damage to bridges and impede the safety of traffic. Thus, efficient axle load regulation will lead to a reduction in maintenance cost to the road keeper, i.e., the government. (2) On the other hand, enforcing a strict regulation will imply that excessive payload on overloaded vehicles must be transported by additional vehicles and hence increase vehicle-kilometres driven by heavy vehicles. These added vehicle-kilometres will increase the cost of moving any given volume of goods for road hauliers. The costs associated with this second impact may to some extent counteract the gains associated with reduced wear and tear on roads. The economic assessment has therefore focused on these two major impacts, rather than on the total Axle Load Programme per se.

The results of this study are:

The enforcement of the axle load regulations will lead to savings in the cost of road maintenance for the road keeper (the Zambian government). The savings will be manifested in longer time intervals between rehabilitation of different road segments. The average annual savings are estimated to be of the order US $4-4.1 million per year. Discounted over 15 years with 6 per cent rate of interest, this amounts to a present value of US $41 million. Thus, in terms of future savings in road maintenance, the programme is profitable.

However, the estimated increase in annual road haulage cost is estimated to be of the order of 12-13 million US $, i.e. about three times the savings in road maintenance. Excluding transit traffic, the added cost of road haulage is a cost to producers and consumers in Zambia. The current GVM limit of 56 tonnes is an improvement over the limit of 55 tonnes. The 12-13 million US $ represent potential savings from increasing the GVM limit even further, to the more realistic 60 tonnes.

The main reason for the high increase in the cost of road haulage is the GVM regulation. The regulation effectively constrains payload per trip for heavy goods vehicles. The weight of very heavy goods vehicles generally exceeds the recently approved GVM limit of 56 tonnes before the axle load restrictions come into force. Thus, the GVM regulation by itself has a negligible impact on road wear when the axle load regulations are efficiently enforced.

The newly approved maximum GVM of 56 tonnes is expensive for Zambia in terms of transport costs, although it is an improvement over the previous regulation of 55 tonnes. However, it is worth noting that the limit is set regionally by SADCC, mainly as precaution for bridges, and not by Zambia alone. Because a higher GVM limit would be less expensive, the proposal to gradually increase the limit is a move in the right direction.

It has not been possible to evaluate the optimal GVM for Zambia, due to the fact that information on the strength of bridges in Zambia is very scarce. The need for data on bridges should be stressed.

Finally, the quality of data from the baseline study of 2002 - 2004 and from the benchmark study of 2005 has been good relative to that of other developing countries. However, there is room for improvement. We recommend the programme improves the quality of data collection, especially with respect to origin and destination of vehicles and types of goods transported. Further, the programme should ensure that measurements are both precise and representative.

While the effect on road deterioration is the main motivation for a programme attempting to reduce overloading, the programme may have additional benefits, depending on the specific circumstances. These would include: (i) A comprehensive scheme with efficient weighbridges will provide valuable information on the roads exposure to heavy traffic. In the future, this information can be used in the design of maintenance programmes and to set the appropriate design parameters for roads to be built or rehabilitated, (ii) Training of officers both in administration and operation of the control scheme contributes to a general improvement of skills for the workforce, (iii) The programme can contribute to a more general awareness of the corruption problem and set an example in this respect, (iv) Information about programme and its objectives can improve the general awareness of truckers when it comes to problems caused by overloading, (v) The programme will promote fair and efficient competition in the trucking industry by not given a competitive advantage to operators that don’t comply with the rules and regulations pertaining to loading of vehicles, (vi) Depending on the level on non-compliance with the regulations, the fines collected from overloaded vehicles may generate revenues exceeding the cost of operating the programme and thus provide additional funding for road maintenance. However, if the programme is efficient, the rate of compliance will – in the longer run - be high and the revenue consequently low.

These additional benefits have not been possible to measure in monetary terms and will only occur if the programme continues in the future with the intended level of efficiency. If that happens, these benefits alone may well outweigh the negative impacts of the programme which are the extra costs imposed on road hauliers due to GVM restriction. Our observations are that these benefits are currently being realised as the programme moves forward.

Preface

This report presents the results of a socioeconomic impact assessment of regulating and enforcing axle load regulation in Zambia. An Axle load programme is currently being implemented by the Zambian government. We identify the advantages and disadvantages of this programme on the Zambian economy. Our report builds largely on an axle load baseline study for Zambia carried out in 2002 – 2004, a benchmark study conducted in 2005, the HDM manuals recommendation on equivalent standard axle load and the Axle Load Study for Southern Africa, 1993.

The study is a joint effort between Molde Research/Molde University College and the Norwegian Public Roads Administration. Professor Odd I. Larsen from Molde Research/ Molde University College, Norway has served as a consultant. Dr James Odeck has served as project manager and Researcher Anne Kjerkreit has been project assistant, both of whom are from the Norwegian Public Roads Administration. This report has been written and compiled by all the above named researchers.

Molde, September 2008
Molde Research, Molde

Acknowledgements

This study is a collaborative evaluation effort by the Molde Research, Molde, Norway, The Norwegian Public Roads Administration (NPRA) and the Axle Load programme of Zambia. It was prepared by Professor Odd I. Larsen of Molde Research/ Molde University College and Dr. James Odeck and Researcher Anne Kjerkreit, both of whom are from the Norwegian Public Roads Administration. Financing was provided by the NPRA.

Bjørn Kåre Steinseth (NPRA) contributed to the design of the study. Cosmas Lungu and Grace Mutembo (Axle load control programme, Zambia) made valuable contributions, especially regarding data collection. Jan Tore Odd and Mhango (Axle load control programme, Zambia) provided invaluable information on the overall running of the axle load control programme.

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Executive summary

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The results of this study are:

1. The enforcement of the axle load regulations will lead to savings in the cost of road maintenance for the road keeper (the Zambian government). The savings will be manifested in longer time intervals between rehabilitation of different road segments. The average annual savings are estimated to be of the order US $4-4.1 million per year. Discounted over 15 years with 6 per cent rate of interest, this amounts to a present value of US $41 million. Thus, in terms of future savings in road maintenance, the programme is profitable.

2. However, the estimated increase in annual road haulage cost is estimated to be of the order of 12-13 million US $, i.e. about three times the savings in road maintenance. Excluding transit traffic, the added cost of road haulage is a cost to producers and consumers in Zambia. The current GVM limit of 56 tonnes is an improvement over the limit of 55 tonnes. The 12-13 million US $ represent potential savings from increasing the GVM limit even further, to the more realistic 60 tonnes.

3. The main reason for the high increase in the cost of road haulage is the GVM regulation. The regulation effectively constrains payload per trip for heavy goods vehicles. The weight of very heavy goods vehicles generally exceeds the recently approved GVM limit of 56 tonnes before the axle load restrictions come into force. Thus, the GVM regulation by itself has a negligible impact on road wear when the axle load regulations are efficiently enforced.

4. The newly approved maximum GVM of 56 tonnes is expensive for Zambia in terms of transport costs, although it is an improvement over the previous regulation of 55 tonnes. However, it is worth noting that the limit is set regionally by SADCC, mainly as precaution for bridges, and not by Zambia alone. Because a higher GVM limit would be less expensive, the proposal to gradually increase the limit is a move in the right direction.

5. It has not been possible to evaluate the optimal GVM for Zambia, due to the fact that information on the strength of bridges in Zambia is very scarce. The need for data on bridges should be stressed.

6. Finally, the quality of data from the baseline study of 2002 - 2004 and from the benchmark study of 2005 has been good relative to that of other developing countries. However, there is room for improvement. We recommend the programme improves the quality of data collection, especially with respect to origin and destination of vehicles and types of goods transported. Further, the programme should ensure that measurements are both precise and representative.

While the effect on road deterioration is the main motivation for a programme attempting to reduce overloading, the programme may have additional benefits, depending on the specific circumstances. These would include: (i) A comprehensive scheme with efficient weighbridges will provide valuable information on the roads exposure to heavy traffic. In the future, this information can be used in the design of maintenance programmes and to set the appropriate design parameters for roads to be built or rehabilitated, (ii) Training of officers both in administration and operation of the control scheme contributes to a general improvement of skills for the workforce, (iii) The programme can contribute to a more general awareness of the corruption problem and set an example in this respect, (iv) Information about programme and its objectives can improve the general awareness of truckers when it comes to problems caused by overloading, (v) The programme will promote fair and efficient competition in the trucking industry by not given a competitive advantage to operators that don't comply with the rules and regulations pertaining to loading of vehicles, (vi) Depending on the level on non-compliance with the regulations, the fines collected from overloaded vehicles may generate revenues exceeding the cost of operating the programme and thus provide additional funding for road maintenance. However, if the programme is efficient, the rate of compliance will – in the longer run - be high and the revenue consequently low.

These additional benefits have not been possible to measure in monetary terms and will only occur if the programme continues in the future with the intended level of efficiency. If that happens, these benefits alone may well outweigh the negative impacts of the programme which are the extra costs imposed on road hauliers due to GVM restriction. Our observations are that these benefits are currently being realised as the programme moves forward.

1. Introduction

The Zambian government considers the road sector as one of the most important sectors of its economy because roads promote efficiency in both the private and the public sector, which is a prerequisite for the alleviation of poverty and economic growth. Hence, the Government of Zambia has in the recent years embarked on several measures to improve the road network. One of the areas of great concern is the prevalent overloading of heavy vehicles.

Building on regional initiatives recommended by the COMESA agenda for the transport communication in the region, Zambia has developed its axle-load control initiative called "A Process Related Axle Load Control Programme for Zambia". The initiative was taken by the Zambian Road Authority and the donor community in 2001 to develop a programme and establish a project with a time frame of four years to recover control over the overloading situation and hence control over the deteriorating road standards. The project started officially in June 2004 and is supposed to end in June 2008. Currently (2007), the programme has led to the approval and implementation of a new regulation on maximum permissible axle loads and gross vehicle mass (GVM). The regulation is effectively being enforced. The planning and initial phase of the programme is being funded by the Norwegian Government based on institutional co-operation between the road authorities in Zambia and the Norwegian Public Road Administration (NPRA).

Specifically, the program has resulted in the following:

1. The permitted Gross Vehicle Mass (GVM) has been increased from 55 to 56. However, while the new limit of 56 is being enforced effectively and with success, the former limit was not enforced. Thus, before the new regulations, transporters could effectively utilize GVM above 56. Thus, while the new regulation will lead to cost savings for the road keepers (i.e., the government) in the form of reduced maintenance costs, it incurs additional costs for the road hauliers who now must transport their goods with additional trips.

2. Besides the impact of axle load control named above, the program has several additional intangible benefits and these include (i) a comprehensive scheme with efficient weighbridges that will provide valuable information on the roads' exposure to heavy traffic (ii) the training of officers both in administration and operation of the control scheme that will contribute to a general improvement of skills for the workforce and, (iii) information about the programme and its objectives which can improve the general awareness of truckers when it comes to problems caused by overloading.

This report is a socioeconomic impact assessment of the above named programme where the aim is to reveal the programme's impact on the Zambian economy. Because of the current stage of the programme, the study focuses on the impacts of regulating and enforcing axle load regulation as part of the wider Axle Load Control Programme. It thus concentrates more on the tangible impacts addressed in (1) above.

The remainder of this report is organized as follows. Section 1.1 elaborates on the rationale for this study. Chapter 2 describes the assessment framework employed, Chapter 3 discusses the data used and Chapter 4 illustrates the assessment framework by applying the methodology developed to survey data from Livingstone. Chapter 5 derives the overall results while Chapter 6 provides concluding remarks.

1.1. The rationale for the study

The rationale for this study is that the government of Zambia has embarked on axle load programme and needs to know the programmes overall economic impact on the Zambian economy. The questions that should be addressed are what are the benefits and costs, and whether the benefits exceed the costs.

The reason for having legal axle load limits and control of the road users' compliance with the limits is that vehicles with too heavy axles destroy roads and hence impose an extra cost onto society in terms of future costs of road maintenance and rehabilitation which must be financed by the government. On the other hand, axle load control implies that goods will have to be moved on more vehicles and therefore the costs for road haulage will increase. If the additional costs for road haulage exceed savings then axle load control would cause "excessive" cost for society. It is worth emphasising here however, that excessive loads are not necessarily the only reason for observed premature deterioration of roads. The same effects can be caused by sub-standard construction or maintenance or more heavy traffic than the road was initially designed for. Pavements are also subject to an aging effect. Thus not all premature deterioration should be accredited to overloading of heavy vehicles.

There are other advantages or disadvantages of overloaded vehicles that must also be considered when evaluating legal axle load limits. Overloaded vehicles lead to reduced traffic safety for third parties. A heavily loaded vehicle will need longer braking distances to come to a full stop from a given speed than the same type of vehicle with a lighter load. By this argument a heavily loaded vehicle should be more prone to be involved in accidents. But the relationship is not straightforward. Lighter loads on trucks in general will cause the payload to be distributed on more vehicles and vehicle-kilometres and also lead to higher average speeds since heavy loads tends to reduce the average speed. An increase in vehicle kilometres and average speeds will also increase the risk of accidents and partly counteract the effects on traffic safety of reduced overloading. In order to sort out the aggregate net effect of reduced loads on traffic safety, a large database on traffic accidents with comprehensive information on each accident is needed. To our knowledge, no such database exists and no study has previously been carried out that really addresses this issue.

Extreme overloading with respect to GVM can, in some cases, also pose a risk with respect to breakdown of bridges and other structures, but this will to a large extent depend on the design standards used for infrastructure and on the present condition of the infrastructure.

While the effect on road deterioration is the main motivation for a programme to reduce overloading, the programme itself may have some additional benefits depending on the specific circumstances, which are difficult to measure and will only materialize if the programme continues into the future with the intended level of efficiency. In the case of Zambia we can point to the following aspects:

- A comprehensive scheme with efficient weighbridges will provide valuable information on the roads exposure to heavy traffic. This information can be employed in the design of maintenance programmes and to set the appropriate design parameters for roads to be built or rehabilitated.
- Training of officers both in administration and operation of the control scheme contributes to a general improvement of skills for the workforce.
- The programme can contribute to a more general awareness of the corruption problem and set an example in this respect.
- Information about the programme and its objectives can improve the general awareness of truckers when it comes to problems caused by overloading.
- The programme will promote fair and efficient competition in the trucking industry by not giving a competitive advantage to operators who do not comply with the rules and regulations pertaining to loading of vehicles.
- Depending on the level on non-compliance with the regulations, the fines collected from overloaded vehicles may generate revenues exceeding the cost of operating the programme and thus provide additional funding for road maintenance. However, if the programme is efficient, the rate of compliance will, in the longer run, be high and the revenue consequently low.

This report evaluates economic impact of the axle programme for Zambia with emphasis on the benefits for the government in terms of reduced future costs of road maintenance and rehabilitation and in terms of additional cost for hauliers due to the fact that the programme implies increased transport costs. The study does not take into account the other benefits that are difficult to measure; rather, it assumes that they will be positive if the programme is conducted efficiently.

2. Assessment Framework

In general, a programme for overload control can briefly be sketched as follows:

> An initial investment is made in the programme. This investment can be in the form of information campaigns, setting up administrative procedures, training programme officers and acquiring equipment/infrastructure for weighing vehicles. The programme will also have an annual operating cost related to operation and maintenance of weighbridges (mobile or permanent). It will also generate some direct revenues from fines on overloaded vehicles.

The question is: *On what condition will this programme be profitable from an economic point of view?*

If we look strictly at transport and expenditures on roads, the answer is *in principle* simple:

> Assume that we have an initial situation where a certain share of the road transport is carried out by overloaded vehicles. The impact of these transports in terms of premature road deterioration can be indicated by the ESAL-kilometres[1] they represent and the total costs in terms of road deterioration can be calculated by multiplying the number of ESAL-kilometres by the appropriate cost per ESAL-kilometre.
> An efficient programme to curb overloading will lead to a redistribution of the payload on the overloaded vehicles and thus cause additional vehicle trips, i.e. the total number of vehicle-kilometres will (supposedly) increase, but the ESAL's per vehicle-kilometre will in percentage terms be reduced more and the total effect should be a reduction in the ESAL-kilometres on the roads.
>
> We must expect that a fraction of the overloaded axles stems from an unequal distribution of the load on the axles of the vehicles. Thus, reducing some of the overloading will only require a more careful loading of the trucks. This only demands that more attention is paid to the distribution of the payload on the axles of a vehicle. Consequently, some of the overloading can be reduced at negligible cost to the transporters or freight owners.
>
> An additional effect can be that some of the transports are shifted to rail if rail is competitive.
>
> The savings related to road deterioration will be equal to the reduction in ESAL-kilometres multiplied by the cost per ESAL-kilometre. However, in order to arrive at the net social benefits we must deduct the increase in transport cost due to additional vehicle trips and vehicle-kilometres. *A cost/benefit assessment can be based on the present value of net social benefits calculated in this way in comparison with the present value of programme cost.*

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[1] ESAL is an abbreviation for "Equivalent Standard Axle Load" and a standard axle is usually defined as a single dual wheel axle with a load of 8.16 tonnes. Using conversion factors, any combination of vehicle type and weight on axles can be converted into the equivalent number of standard axle loads (ESALs), see ch 3 (p 13) for more details. The assumption is that an axle with a load that gives the equivalent of 2 ESALs does twice as much road damage as a standard axle.

There are actually two issues involved here:

1. The legal axle load limits
2. The optimum maximum axle loads

An optimum maximum axle load is defined as the axle load that minimizes the sum of the costs for the road hauliers and the road keeper for a given volume of freight to be moved between a set of origins and destinations. This optimum will also minimize the cost to society of moving the freight, possibly with some minor modifications due to impact on traffic safety and other aspects.

The ideal is that the legal axle load limit coincides with the optimum. However, this is not necessarily the case. The SADCC "Axle Load Study"[2] (later referred to as SAxLS) estimated the optimum for a "standard axle"[3] to be close to 13 tonnes, while the legal limit for a "standard axle" in Zambia is 10 tonnes at present. A legal limit of 13 tonnes has also been adopted as a long term goal for SADC as stated in the official document for the programme[4]:

"SADC has recommended an adjustment in the allowable axle load and gross vehicle mass limits in Southern Africa. The SATCC recommendation for the adjustment of axle-load limits in the region refers to two standards:

1. A short - term perspective to allow 10 tonnes for a single dual wheel axle in the member states
2. A long - term perspective to phase in the recommended SADC 13 tonnes axle-load limit"[5]

Thus a programme that causes a decrease in the number of equivalent standard axles in the range of 10-13 tonnes may actually increase total transport cost even if the costs of road keeping are reduced. It will only be a reduction in loads exceeding 13 tonnes that will actually produce any net social benefits.

In order to evaluate the benefits of the programme we need to know how the programme will affect the number and distribution of ***tonne-kilometres*** on different axle loads. Axle load surveys carried out at specific points in the road system by themselves do not provide an answer to this question.

The new Zambian regulations pertaining to axle loads and GVM impose a maximum GVM of 56 tonnes that applies to vehicles with 7 or more axles. This is an improvement

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[2] Institute of Transport Economics and Carl Bro International A/S (1993): "Axle Load Study for Southern Africa – Final Report". TØI-report 180/1993

[3] A single axle with dual wheels is commonly used as a reference in the literature and termed a standard axle.

[4] A PROCESS RELATED AXLE-LOAD CONTROL PROGRAMMEME FOR ZAMBIA Revised and Final Document December 2003, MINISTRY OF WORKS AND SUPPLY ROADS DEPARTMENT, p15

[5] This refers to a "standard axle", i.e. a single dual wheel. For axles in combinations the optimum load will be lower.

over the previous regulation that only allowed 55 tonnes of GVM. From the point of view of transport cost, a GVM of 56 tonnes is actually a more severe restriction than the permitted maximum axle loads. For trucks with more than 7 axles and a relatively even distribution of the load among the axles, this regulation will come into force before the regulations on axle loads becomes an effective constraint on payload.

An example to illustrate the issue:

Assume that 1000 tonnes of some type of cargo will be moved between two places over a distance of 200 kilometres. Assume also that the density of the cargo is such that it can be moved on overloaded vehicles. If vehicles are loaded to what corresponds to 15.8 tonnes on a standard axle, the cost per tonne-kilometre (including wear and tear on roads and bridges and operating and capital cost of vehicles) may be of the order of 6 US cents and the total cost US $12000. If this load is moved on vehicles that are optimally loaded (≈13 tonnes per standard axle) the average social cost per tonne-kilometre will decrease to 4.9 US Cent and the social savings becomes US $2200.

However, if control and fees for overloading transfers this transport to vehicles loaded to the legal limit (10 tonnes), the average cost per tonne-kilometre will only decrease to 5.4 US Cent, the social savings will only be US $1200. All the same it amounts to a 10 per cent saving on the total social cost of a transport involving 200 000 tonne-kilometres.

In order to calculate the benefits of a programme to curb overloading, we thus need an estimate of ***tonne-kilometres moved on overloaded axles in different intervals of overload***.

Furthermore ***we need an estimate of how these tonne-kilometres are affected by the programme, i.e. how many additional vehicle kilometres will be needed and the impact on total ESAL- kilometres.*** A programme will never be 100 per cent effective. The effectiveness will depend on the density and frequency of overweight controls and on the fines paid for overloading and possibly on the prevalence of bribing in the system.

Thus we can only assume that a certain fraction of freight on the overloaded axles will be transferred to lower weight intervals and ***we need an estimate of this fraction***.

The SADCC Axle Load Study is an extensive study on the axle load issue and the relationships between costs and axle loads developed in this study can be used as a basis for calculating savings.

3. Data

The background for the axle load control was the combination of observed road deterioration and measurements of actual loads at selected points. The initial measurements of axle- and vehicle weights are documented in “The Axle Load Baseline

Study, 2002-2004, Final Report" (later referred to as BLS). This study is based on short term surveys carried out in the period September 2002 to January 2004 at 10 sites.

The axles of the vehicles were weighed and gross vehicle mass was calculated. The executive summary of the report states:

> "The axle load baseline study has shown that the overloading is not that excessive as previously thought. Nevertheless, 19.5 % of all (weighted axles from the 10 survey sites) the axles are > 10 tonnes. The figure drops to 5.4 % for axles > 12 tonnes. The proportion of axles > 14.0 tonnes were 1.3 %. The highest axle load measured during the survey was 23.0 tonnes, however axle loads between 16-19 tonnes were measured frequently." [6]

In our opinion the report actually understates the severity of the overloading problem due to the way that overloading is assessed, even if the statement above is correct when it comes to distribution of the axle loads.

The reference to the weighed axles assumes that the all type of axles with the same load cause the same damage to the roads. However, there is a reason for differentiating between axle types both in regulations and in assessment of damaging effect.

The HDM-manual recommends that the following loads are used for to give an equivalent standard axle load (these figures are also used in SAxLS):

Axle weights giving on ESAL

Axle type:	Load equivalence for 1 ESAL (tonnes)
Steering axle	6.60
Dual-wheel single axle (standard)	8.16
One dual wheel axle in tandem	7.55
One dual-wheel axle in triple	7.63

Thus 12 tonnes on <u>one</u> dual wheel axle in a tandem combination is assumed to do much more damage than 12 tonnes on a single dual wheel axle. How much more depends on the exponent used in the calculation. The baseline study uses 4.55 for the exponent in the "load equivalence law" while the default in HDM is 4 and the there is also evidence that suggest a still lower exponent (see for example Small et al, 1989). With an exponent of 4, 12 tonnes on a standard axle gives 4.68 = $(12/8.16)^4$ ESALs while 12 tonnes on a one dual wheel in tandem combination gives 6.38 ESALs =$(12/7.55)^4$, i.e. 36 % more. Using 8.16 tonnes and 4.55 we get $(12/8.16)^{4.55}$ = 5.78 ESALs.

Assume that we have a semi-trailer (1.22-222) with weights {7, 9 ,9.5, 10, 8.5 , 11 } tonnes on the 6 axles. The ESALs are then calculated as:

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[6] The very high axle loads measured in some instances are probably due to A12 combinations with faulty suspension.

$$\text{ESALs} = (7/6.6)^4 + (9/7.55)^4 + (9.5/7.55)^4 + (10/7.63)^4 + (8.5/7.63)^4 + (11/7.63)^4 = 14.6$$

Thus, while the exponent of 4.55 in our opinion is too high, the treatment of all axle-types as equal in terms of damaging effect will all the same lead to an underestimation of the ESALs caused by overloaded vehicles. The efficient way to regulate permitted axle loads is obviously to take this fact into consideration and differentiate between axle types, and this is also case in the Zambian regulations.

The exponent used has two effects when it comes to calculating ESALs. A high value for the exponent will give a higher ESAL estimate for high loads, but it will also give a lower estimate of ESALs for lower loads.

Figure 1 gives an example of the difference in ESAs between the original estimates in BLS and calculated with exponent 4 and equivalence weights for different types of axles taken from HDM. The example is based on 20 semi-trailers weighed at Livingstone in September 2002.

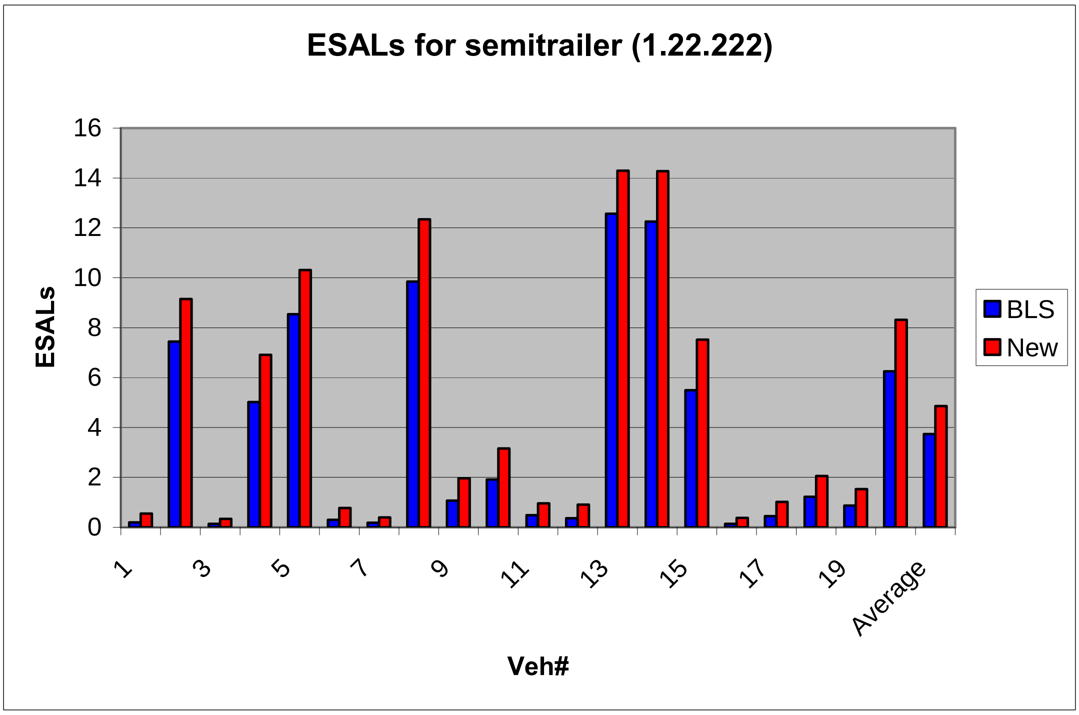


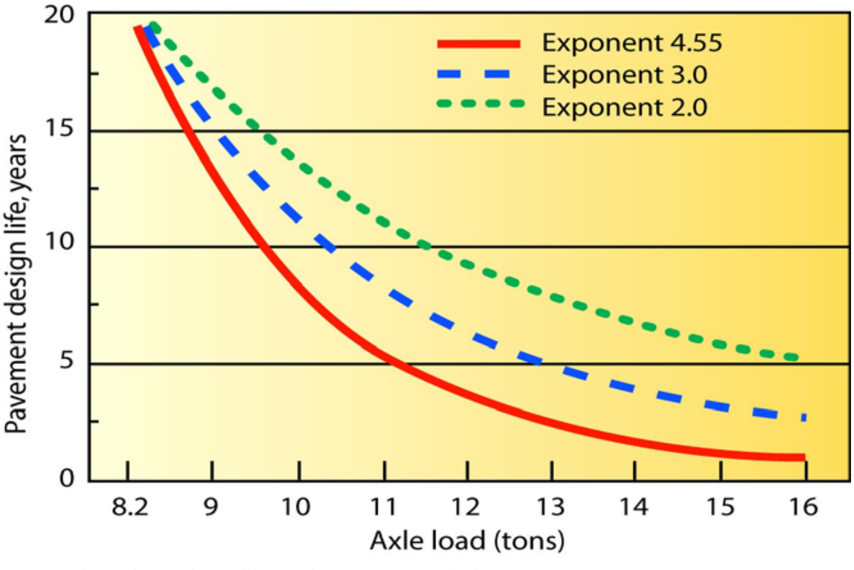
Figure 1: Example of differences in calculated ESALs – 20 semi-trailers weighed at Livingstone in September 2002.

The total ESAs increased by 30 per cent for this sample of 20 vehicles when calculated by using the equivalence weights from HDM and exponent 4. Thus, while an exponent of 4.55 is too high according to most evidence, the use of exponent 4 in conjunction with equivalence weights for different axle-types tends to give higher ESA estimates than an exponent of 4.55 and an equivalence weight of 8.16 tonnes for all axel types. The principle used to calculate ESALs may thus have considerable consequences for an assessment of the cost of overloading since the cost of road wear is directly related to the ESALs. In this survey 62 semi-trailers were weighted in direction Livingstone and the increase in estimated total ESALs was 12.3 per cent for these vehicles. The sum for both directions was an increase in calculated ESALs of 18 per cent.

It must be admitted that both the equivalence loads for different axle types and the exponent in the "load equivalence law" are uncertain and that research over the years has given no final verdict on these issues. However, we prefer to stay with the recommendations in the HDM-manual in this study.

The exponent expresses, in a sense, the consequences in terms of road wear of increasing the payload on a given number of axle-kilometres. The consequence of curbing overloading, however, is not to reduce the payload on a given number of axle-kilometres, but mainly to distribute the payload on a greater number of axle-kilometres. This also increases the total tonne-kilometres on the roads by the tare weight of the additional axle-kilometres.

This is why a figure like Figure 6.3 in BLS (reproduced below) grossly overstates the impact on pavement life from a reduction in axle loads. It only gives a true picture of the service life of a pavement for the case where the total payload is changed for a given number of vehicle trips - all loaded to the limit. For the realistic case where only a fraction of the axles is loaded to limit indicated on the x-axis and the number of axles increases when the load per axle decreases the consequences for pavement life of increasing axle loads are much less severe.



Source: The Axle Load Baseline Study, 2002-2004, Final Report

Figure 2 (adopted from SAxLS Figure 7.2.1 p 72) shows the difference between the produced ESALs when *payload increases on a given number of axles* and *when payload is constant and the number of axles carrying this payload decreases*. ESALs/tonnkm in this figure should provide the realistic picture of what happens to road deterioration, while much of the engineering literature bases the argument on the curve for axle-kilometres. The difference between these two curves is the main reason why the "optimum axle load" becomes, seemingly, quite high. Figure 3 is adopted from the base case of SAxLS. The base case shows a 6-axle semi-trailer (1.22_222) and uses the equivalence loads for different axles recommended in HDM. We see that above 1.8 (equivalent to 14.8 tonnes on a standard axle) the total cost rises steeply, but this is mainly due to wear and tear on (short) bridges caused by dual and triple axles. The development of the cost component for road wear follows the curve for ESALs per tonne-kilometre in Figure 2.

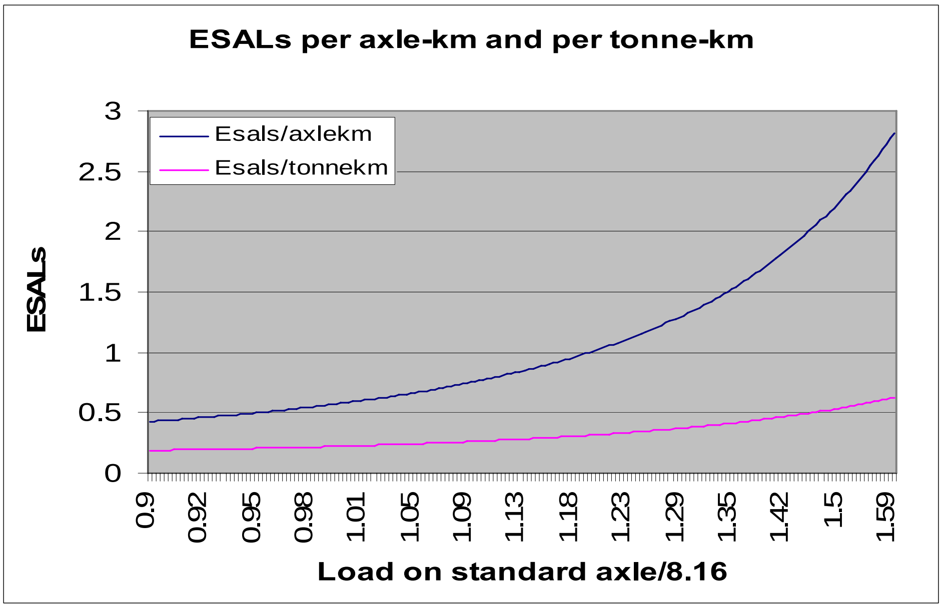


Figure 2: ESALs as a function of axle loads

Source: Axle Load Study for Southern Africa (Fig. 7.2.1)

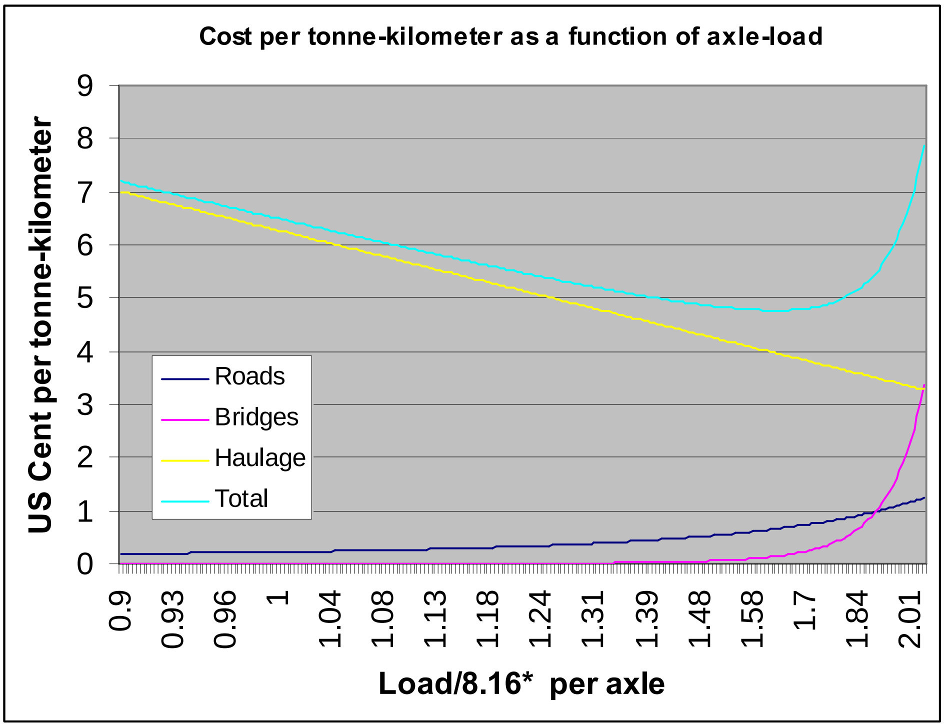


Figure 3: Costs and axle-load

Source: Axle Load Study for Southern Africa (Fig. 2.1)

4. Application of methodology to survey data at Livingstone

The surveys in BSL are a starting point for assessment of the impact on the total cost of road transport. We will mainly use the surveys in BLS because they have been carried out with a common methodology and the axles in different combinations were weighed separately. We must also expect that the programme up until now has had some effects on overloading. Thus in order to capture the full effects of the programme, the BLS surveys should be the proper reference point.

Even if the surveying was done for different sites and at different times a certain problem is involved. This can be seen by imagining that control at the sites was continuous over the year. It that case, it is easy to realize that the same vehicle with the same load could be observed and weighed at two or more sites. As costs are related to ESAL –kilometres and vehicle kilometres, care must therefore be used in interpreting the results from the survey sites in terms of costs. There is an obvious danger of double and triple counting of ESAL-kilometres and vehicle-kilometres.

A percentage of the vehicles weighed does not comply with the regulation pertaining to GVM and/or maximum axle load limits. If a vehicle does not stay within the limits for

GVM, it will obviously have excessive payload and the excessive payload has to be redistributed to other vehicles.

A vehicle that stays within the permitted GVM, but has excessive load on one or more axles, will usually be able to stay within the permitted axle load limits by distributing the payload on the vehicle more evenly between the axles. However, this possibility will also depend on the type of load. It is not all types of commodities that can be redistributed freely on axles. An obvious example is tank lorries.

We will initially use the semi-trailers and MVGs weighed at Livingstone in September 2002 as an example. It is noted in BLS that the number of vehicles in the survey was influenced by a drought relief programme the entailed an estimated 30 per cent increase in heavy vehicles over the "normal" level of traffic. The 2002 survey is therefore only used for the examples below, but the 2004 survey is used in the estimation of total cost and benefits.

4.1. Semi-trailers at Livingstone

For the configuration 1.22-222, maximum permissible GVM in the new regulations is 50 tonnes. The maximum axle loads are[7]:
Steering axle : 8 tonnes
Tandem axle : 18 tonnes
Triple axle : 24 tonnes

In the new regulations, the axles have a 5 per cent allowance, but no allowance is given for GVM. Loaded to 50 tonnes GVM, a reasonable estimate of ESALs produced by this type of vehicle (1.22-222) is:
$(7.5/6.6)^4 + 2*(18.25/15.1)^4 + 3*(24.25/22.89)^4 = 9.7$ *ESALs*
The payload with GVM=50 tonnes is approximately 36 tonnes.

Table 1: Semi-trailers (1.22-222) with respect to type of overloading-direction Livingstone, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	15	85.4	291.3	145.5
Only on axles	7	0	63,6	50.6
No overloading	40	0	73.6	73.6
"New vehicles"	(2.4)	0		23.0
Total	62	85.4	428.5	292.7

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[7] The Public Roads Act, The Public Roads (Maximum Weight of Vehicles) Regulations, 2007, First and Second Schedule.

Let us assume that the excessive payload is removed from the 15 vehicles and that the remaining load is distributed on the axles without overloading, i.e. 9.7 ESALs per vehicle. For these 15 vehicles the ESALs will then be 145.5. To take the excessive payload, 2.4 vehicles of this type are needed and these vehicles will add 23 ESALs.

If the payload is redistributed on the 7 vehicles with only overload on the axles, the ESALs on these vehicles can be reduced to 50.6 with an optimum distribution of the load, i.e. the distribution of load on the axles that minimizes ESALs subject to the measured GVM for each vehicle. Thus, if the same payload is moved on vehicles that comply with the regulations, the ESALs will be reduced by roughly one third.

Unfortunately, no information is available on the origins and destinations of the surveyed vehicles. These vehicles will, however, mainly be engaged in international traffic, including transit traffic, and the distance from Lusaka to Livingstone is probably a reasonable estimate of the average trip length within Zambia. Thus, as an example, we will use 500 kilometres. The survey period was one week. If this week is representative with respect to the volume of traffic and the loads, the results can be multiplied by 52 to get an estimate of annual figures.

The SAxLS estimated the cost of road wear to be approximately 1 US Cent per ESAL-kilometre, but to be on the safe side we put present day costs at 1.5 US Cents[8]. Thus, if compliance with the regulations are enforced, for these (original) 62 vehicles we have an estimated annual saving in road maintenance cost of:

(428.5- 292.7)*0.015*500*52 = 52960 US $

This is for the part of the tonne-kilometres that by assumption is on the Zambian roads. From Figure 2 we can see that only axles where (load/equivalent weight) > 1.6 will have a noticeable impact on the wear of short bridges. Of the axles on these weighted vehicles only 6 (out of 372) is above 1.6. The bridge wear component in the cost is thus insignificant for the observed loads.

The main offsetting cost is the cost of additional vehicle trips. If these are empty on the backhaul, it will involve a minimum of 2.4*500*2*52 = 124800 vehicle kilometres to move the excessive payload on an annual basis. Again using the assumption from SAxLS, the economic vehicle operating cost per kilometre for a semi-trailer running empty is US $1.25[9] and we get an estimate of the additional cost of trucking that amounts to:

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[8] The estimated (marginal) cost per ESAL in SAxLS was based on an estimated cost of road rehabilitation of 160 000 US $ per kilometre. Current estimates for Zambia are 180 000 US $ per km, i.e. an increase of 12.5 per cent.

[9] The simplifying assumption is that a given payload will cause the same addition to fuel consumption however it is distributed on vehicles. Then it is sufficient to focus on operating costs for empty vehicles. The original estimate SAxLS for this vehicle category was 1.22 US $ per vkm.

124800*1.25 = 156000 US $

If we have a completely symmetric overloading problem with respect to directions, the savings in road maintenance cost will double, but the 2.4 vehicles can in principle be used in both directions and the increase in trucking cost will remain as estimated.

The ESALs of an empty semi-trailer is approximately 0.05 and these empty vehicle trips will add an additional 0.05*500*52*0.015*2.4= 47 US $ to road maintenance cost which is insignificant.

Thus, depending on the directional balance in payload we will have a savings in road maintenance cost that varies between 52960 US $ and 105920 US $ and an additional cost of trucking of the order 156000 US $.

In the same period 69 trucks going in the direction of Mazabuka were weighed. Doing the same calculations for these trucks we obtain the figures in Table 2.

Table 2: Semi-trailers (1.22-222) with respect to type of overloading –direction Mazabuka, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	22	116.0	381.8	213.4
Only on axles	12	0	123.1	93.2
No overloading	35	0	138.5	138.5
“New vehicles”	(3.22)	0		31.3
Total	69	85.4	643.4	476.4

This implies a saving in the cost of road maintenance of:

(643.4 – 476.4)*.015*500*52 = 65130 US $

The additional vehicle trips imply a cost of:

3.22*1.25*500*2*52= 209320 US $

If we make the assumption that these 3.22 trucks also are used to take the overload in the opposite direction, the calculation shows a saving in road maintenance cost off:

52960 US $ + 65130 US $ = 118090 US $

The net result for trucking cost and road maintenance cost thus becomes **a cost increase of:**

209320 US $ - 118090 US $ = 91230 US $ on an annual basis

A result like this is to be expected based on the analysis in SAxLS. Of the total of 786 axles on the 131 semi-trailers, only 15 or 1.9 per cent were above the optimum estimated in SAxLS and thus should have a (mostly rather moderate) reduction in load, while a total of 134 or 17 per cent did not comply with the regulations and had the load reduced in the example.

Semi-trailers with configuration 1.22-222 are rather moderate with respect to GVM. For still longer vehicles like the configurations 1.22-222-22, 1.22-222-222, 1.22-22-22 and 1.22-22-222, the permitted GVM of 56 tonnes will have a greater impact and constitute an effective constraint on payload even if axle loads are within the permitted limits. The reason for a maximum limit on GVM is mainly bridges with long spans even if little is really known about the consequences for these bridges of permitting GVM in the range 50-100 tonnes.

With a maximum GVM of 56 tonnes it will rarely pay to use more than 6 axles on a combination. The additional 6 tonnes of GVM allowed will closely match the tare weight of the trailer, leaving hardly any payload to pay for the additional operating and capital cost of the trailer. Thus, with strict enforcement of the GVM regulation we may expect a shift in the vehicle fleet from combinations with 7+ axles to combinations with 6 axles.

While it is straightforward to assign a cost of road wear to heavy axles and even to the wear on short bridges, there exist to our knowledge no estimates of costs to long bridges related to GVM. The issue is more of an assumed increased risk of a complete breakdown or destruction of a bridge when very heavy vehicles are allowed, but little is known about the magnitude of the risks involved.

However, this precautionary motive involved in setting the maximum permitted GVM will also carry a cost. For the four configurations mentioned above we have also carried out a calculation similar to tables 1 and 2.

For all these vehicle categories the maximum permitted GVM of 56 tonnes will be the effective constraint on payload rather than axle load regulations.

The calculations from tables 1 and 2 were repeated for the categories mentioned above:

Table 4: Semi-trailers (1.22-22-22) with respect to type of overloading-direction Livingstone, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	25	339.7	886.6	237.5
Only on axles	0	0	0	0
No overloading	19	0	42.0	42.0
“New vehicles”	(9.4)	0		91.5
Total	44	85.4	928.6	371.0

The assumptions are here that the excessive payload is redistributed to semi-trailers with configuration 1.22-222 as in the previous example. A GVM of 56 tonnes on the original vehicles will produce approximately 9.5 ESALs per vehicle. However, as a consequence of strictly enforced regulations we may expect that trailers with 7+ axles will disappear in the longer run and the payload transferred to 1.22-222 vehicles that produce more ESALs for the same payload.

By the same assumptions the savings in road maintenance cost on an annual basis will be:

(928.6 - 371.6)*0.015*500*52 = 217230 US $

The increase in transport cost will on the same assumptions be:

9.4 * 500*2*52*1.25 = 611000 US $

The same table for the opposite direction yields:

Table 4: Semi-trailers (1.22-22-22) with respect to type of overloading-direction, Mazabuka September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	46	453.1	1134.7	437.0
Only on axles	0	0	0	0
No overloading	14	0	88.2	88.2
“New vehicles”	(12.6)	0		122.1
Total	60	85.4	1222.9	647.3

Thus savings in road maintenance cost can be estimated as:

(1222.9-647.2)*500*52*.015 = 224480 US $

The increase in transport cost becomes:

12.6*500*2*52*1.25 = 819000 US $

Assuming again that these 12.6 vehicles also can take the excessive load in the opposite direction we get a total savings in road maintenance cost for the traffic in both direction of:

(217230 + 224480) US $ = 441710 US $

And the increase in transport cost for both directions will remain at 819000 US $.

Net increase in cost will thus amount to (819000 - 441710) US $ = 377290 US $

Table 5: Semi-trailers (1.22-222-22) with respect to type of overloading-direction Livingstone , September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	21	449.9	755.2	151.2
Only on axles	0	0	0	0
No overloading	5	0	20.2	20.2
"New vehicles"	(12.5)	0		121.2
Total	26	85.4	775.4	292.7

Table 6: Semi-trailers (1.22-222-22) with respect to type of overloading-direction, Mazabuka September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	33	501.9	811.1	237.6
Only on axles	0	0	0	0
No overloading	5	0	13.4	13.4
"New vehicles"	(13.9)	0		135.2
Total	38	85.4	825.0	386.2

Adding ESAL-kilometre savings for both directions we now get: 357670 US $
For added transport cost for 13.9 vehicles per week at 1000 km per roundtrip at US $ 1.25 per vehicle kilometre we get: 903 500 US $ and thus an increase in cost of (903 500-357670) US $ = 545830 US $.

Table 7: Semi-trailers (1.22-222-222) with respect to type of overloading-direction Livingstone, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	34	1533.1	2213.7	139.4
Only on axles	0	0	0	0
No overloading	13	0	23.4	23.4
"New vehicles"	(42.6)	0	0	413.1
Total	47	1533.1	2237.1	575.9

Table 8: Semi-trailers (1.22-222-222) with respect to type of overloading-direction, Mazabuka September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tones)*	*ESALs originally*	*With compliance*
Axles and GVM	52	1792.4	2065.9	213.2
Only on axles	0	0	0	0
No overloading	15	0	34.0	34.0
"New vehicles"	(49.8)	0		483.0
Total	67	1792.4	2099.9	730.2

By the same calculations, the savings in transport cost now becomes 1182050 US $.
The increase in transport cost becomes: 3237000 US $, i.e. an increase in total cost of 2054950 US $.

Finally we do the same calculations for semi-trailers with configuration 1.22-22.222.

Table 9: Semi-trailers (1.22-22-222) with respect to type of overloading-direction Livingstone, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tones)*	*ESALs originally*	*With compliance*
Axles and GVM	7	64.6	120.6	50.4
Only on axles	0	0	0	0
No overloading	16	0	28.3	28.3
"New vehicles"	(1.8)	0	0	17.4
Total	47	64.6	148.9	96.1

Table 10: Semi-trailers (1.22-22-222) with respect to type of overloading-direction, Mazabuka September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	27	339.8	458.6	194.4
Only on axles	0	0	0	0
No overloading	10	0	35.6	35.6
"New vehicles"	(9.4)	0	0	91.6
Total	37	85.4	494.2	321.6

By the same calculations, the savings in road wear cost now becomes 87910 US $.
The increase in transport cost becomes: 611000 US $, i.e. an increase in total cost of 523090 US $.

4.2. MGV – vehicles at Livingstone

The absolute largest vehicle group in terms of number of vehicles surveyed at Livingstone was MVG and the group "1.2". Vehicles in this group have a permitted GVM of 18 tonnes corresponding to axle-loads of 8 and 10 tonnes respectively. A similar calculation for this type of vehicles produce tables 3 and 4.

Table 11: MVG (1.2) with respect to type of overloading-direction Livingstone, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	7	15.1	61.1	30.9
Only on axles	11	0	48.0	35.3
No overloading	157	0	128.0	128.0
"New vehicles"	(1.1)			4.9
Total	175	15.1	237.1	199.1

Table 12: MVG (1.2) with respect to type of overloading-direction Mazabuka, September 2002

Distribution with respect to overload:	*# Vehicles*	*Excessive payload (tonnes)*	*ESALs originally*	*With compliance*
Axles and GVM	1	1.0	8.6	4.4
Only on axles	2	0	8.4	5.6
No overloading	197	0	102.5	102.5
"New vehicles"	(0.07)			0.3
Total	200	1.0	119.5	112.8

Combined for both directions, compliance with the regulations will reduce ESALs by 44.7 or 12.5 per cent compared to 302.8 and 28 per cent for the semi-trailers.

The economic costs involved are also much smaller due to much shorter transport distances. The survey contains no information on transport distances for the loads carried by these vehicles, but as an example we can assume that the average transport distance is 60 kilometres and round trip distance is 120 kilometres.

The savings on road wear will then - on an annual basis - amount to:

44.7 * 0.01*60*52 = 1395 US$

One additional vehicle roundtrip per week with an economic cost of 0.4 US $ per kilometre will on an annual basis amount to:

60*2*0.4*52 = 2496 US$

Thus, even in this case the additional transport costs outweigh the savings on road maintenance. Actually the savings in road maintenance cost obtainable by controlling these small vehicles will hardly pay for the manpower needed as the savings only amounts to 4 US $ per day in this example. It is only justifiable if it can be done by the minimum staff needed anyway for the control of heavy trucks. Traffic safety and overloaded buses is a special issue, but the control at weighbridges may not be the most efficient way to deal with this.

4.3. Total results for the Livingstone survey

Adding up the calculations for the vehicle types in the tables above we get the result in Table 13 for the Livingstone survey. There were some minor vehicle categories in the survey that are not included and they may add a few per cent to the figures for the totals.

For excessive payload for VHGV – vehicles we assume that this is transferred to vehicles with configuration 1.22-222 with a payload of 36 tonnes per vehicle. For MGV the configuration 1.2 is used.

Table 13: Survey Livingstone September 2002 (one week). Sum both directions. Full compliance with regulations

Vehicle type:	*Permitted GVM*	*ESALs, permitted GVM*	*Vehicles surveyed*	*Veh. With excessive payload*		*“New vehicles”*	*Reduction in ESALs*	
	Tonnes		#	#	+ tonnes	**#**		**%**
VHGV ‘semis’			473	282	5675.9	89.9	5613.3	57
1.22-222	50	9.7	131	37	201.4	3.2	302.8	28
1.22-22-22	56	9.5	104	71	792.8	12.6	1133.1	53
1.22-222-22	56	7.2	64	54	951.8	13.9	921.0	57
1.22-222-222	56	4.1	114	86	3325.5	49.8	3031.0	70
1.22-22-222	56	7.2	60	34	404.4	9.4	225.4	35
MGV 1.2	18	4.2	375	8	16.1	1.1	44.7	13
Total			872	290	5692.0	90	5658.0	56

What we have done is recalculate the ESALs for the weighted vehicles by using lower equivalence loads for all axle types except the standard axles (single dual wheel – non steering) and an exponent of 4. This increases computed ESALs compared to BLS by some 20 per cent. Excess payload is removed from vehicles with GVM exceeding the allowed GVM and assigned to "new" vehicles. The number of "new vehicles" are determined by the direction that needs the highest number of "new vehicles" assuming that these are 1.22-222 for 'semis' and take a payload of 36 tonnes. For vehicles with overload on axles but not on GVM, we redistribute the load optimally on the axles and recalculate the ESALs. After these operations the total ESALs are recalculated and deducted from the ESALs calculated for the surveyed vehicles.

This shows that full compliance with the regulations will imply a considerable reduction in ESALs (56 per cent) and consequently also in road wear. However, this method for calculating the new ESALs will probably overestimate the long run impact on ESALs. Here only the "new vehicles" are assumed to have the configuration 1.22-222, but in the longer run more of the freight will probably be shifted to this type of vehicles due to the small additional payload on bigger vehicles when maximum permitted GVM is 56 tonnes. This expected change in vehicle mix will increase the number of vehicle kilometres and the ESALs per vehicle kilometre.

There is no doubt that some of the overloaded vehicles in this survey are extremely overloaded both with respect to GVM and on one or more axles and should not be allowed on the road under any circumstance with the payload they carry. This is also reflected in the very high figures for ESAL-reduction.

In order to convert this reduction in ESALs into cost savings we have to make some assumptions with respect to transport distance and marginal cost per ESAL-kilometre. Based on extensive runs with the HDM-model the SAxLS estimated the road wear cost to be approximately 1 US Cent for typical trunk roads in the SADC-countries. Note that it is the marginal cost that is relevant, not the average cost per ESAL-kilometre that we find by taking the cost of a reconstruction and dividing this by the ESAL-kilometres over the service life of the road. The marginal cost we find by adding or subtracting ESALs for a given road and dividing the change in costs on the ESALs added or subtracted.

For the economic estimates we use the following assumptions. The marginal cost per ESAL-kilometre is 1.5 US Cent or 0.015 US $, i.e. a 50 per cent increase over the base case in SAxLS that was based on a cost of road rehabilitation of 160 000 US $ per kilometre. A vehicle with configuration 1.22-222 has a cost per vehicle-kilometre of 1.25 US $ running empty. This is only a 2.5 per cent increase over the base case in SAxLS.

The payload mainly affects the fuel consumption (except for extreme overloading) and a simplifying assumption is that the fuel consumption saved for the original vehicles when payload is reduced cancels against the additional fuel consumption for the of new vehicles when the payload is added.

In order to avoid a double counting problem we assume that the average distance for payload (on Zambian roads) are 500 kilometres. Thus the “new” vehicle takes the excessive payload in both directions by making a roundtrip of 1000 kilometres. For MGVs we assume an average distance of 60 kilometres and a roundtrip of 120 kilometres with a cost of empty running of 0.4 US $ per vehicle kilometre.

Table 14: Survey Livingstone September 2002 (one week). Sum both directions. Full compliance with regulations

Vehicle type:	*Permitted GVM*	*ESALs, permitted GVM*	*Vehicles surveyed*	*Veh. With excessive payload*		*“New vehicles”*	*Reduction in ESALs*
	Tonnes		#	#	+ tonnes	**#**	
1.22-222	50	9.7	131	37	201.4	3.2	302.8
1.22-22-22	56	9.5	104	71	792.8	12.6	1133.2
1.22-222-22	56	7.2	64	54	951.8	13.9	917.1
1.22-222-222	56	4.1	114	86	3325.5	49.8	3030.9
1.22-22-222	56	7.2	60	34	404.4	9.4	225.4
VHGV ‘Semis’			497	282	5675.9	88.9	5609.4
MGV 1.2	18	4.2	375	8	16.1	1.1	44.7
Total			872	290	5692.0	90.0	5654.1

This gives us the economic consequences directly related to road wear and trucking in Table 14 that gives the cost impacts on an annual basis assuming that the surveyed week is representative.

Table 14. Economic consequences of compliance with regulations – vehicles surveyed at Livingstone August/September 2002 (one week), sum both directions

Vehicle type:	***Road wear , 1000 US $/year***	***Trucking cost, 1000 US $/year***	***Total costs 1000 US $/year***
1.22-222	-118.1	209.3	91.2
1.22-22-22	-441.7	819	377.3
1.22-222-22	-357.7	903.5	545.8
1.22-222-222	-1182.1	3237	2054.9
1.22-22-222	-87.9	611	523.1
VHGV ‘Semis’	-2187.5	5779.8	3592.3
MGV 1.2	-1.4	2.5	1.1
Total	**-2188.9**	**+5782.3**	**+3593.4**

As stated in BLS, the drought relief programme inflated the survey in 2002. Tables 15 and 16 replicate the same results for the semi-trailers using the 2004 survey for Livingstone.

The differences between tables 14 and 16 show the drought relief programme inflated the 2002 survey. Table 16 shows that compared to the 2002 survey the savings in ESALs is reduced by 66 per cent and the excessive payload is reduced by 36 per cent and the number of new vehicles is reduced by 37 per cent.

Table 15. Survey Livingstone January 2004 (one week). Sum both directions. Full compliance with regulations

Vehicle type: VHGV 'Semis'	***Permitted GVM***	***ESALs, permitted GVM***	***Vehicles surveyed***	***Veh. With excessive payload***		***"New vehicles"***	***Reduction in ESALs***
	Tonnes		#	#	+ tonnes	**#**	
1.22-222	50	9.7	122	59	391.8	8.1	453.1
1.22-22-22	56	9.5	40	21	140.2	2.2	129.4
1.22-222-22	56	7.2	51	30	365.4	7.8	187.5
1.22-222-222	56	4.1	105	96	2464.2	34.3	1049.5
1.22-22-222	56	7.2	33	24	270.8	4.4	120.8
Total "Semis"			342	230	3632.4	56.8	1940.3

Table 16. Economic consequences of compliance with regulations – vehicles surveyed at Livingstone January 2004 (one week), sum both directions

Vehicle type: *VHGV 'Semis'*	***Road wear , 1000 US $/year***	***Trucking cost, 1000 US $/year***	***Total costs 1000 US $/year***
1.22-222	-176.7	529.1	352.4
1.22-22-22	-50.5	143.0	91.2
1.22-222-22	-73.1	507.0	432.6
1.22-222-222	-409.3	2229.5	1818.2
1.22-22-222	47.1	288.0	240.9
Total "Semis"	**-756.7**	**+3692.0**	**2935.3**

The main difference between the 2002 and 2004 except for a reduction in vehicles surveyed is the cost increase for the 1.22-222 categories due to more excess payload and a substantially greater directional imbalance in the excess payload. The greater the directional imbalance, the more trucking cost will increase compared to savings in ESALs when axle loads are reduced. Thus the difference between cost savings for road wears and cost increases for trucking becomes even more pronounced in 2004.

> ***It should be emphasised that the results in tables 14 and 16 have nothing to do with the efficiency of the axle load control programme as such. We have assumed that it is 100% efficient, i.e. all overloading with respect to axles and GVM has been curbed.***

The results are a direct consequence of the regulations that are enforced. What the table illustrates is the following mechanisms:

- Some vehicles are extremely overloaded in the economic sense of the term. However, the load for these vehicles is reduced far below the economic optimum and the total net gain therefore becomes small or even negative despite the initial overloading. This corresponds to moving tonnage from a point corresponding to approximately 1.8 on the x-axis in Figure 2 to a point corresponding to 1.25. Total cost will hardly change.
- Some vehicles have loads that are close to - or somewhat below - the economic optimum and the loads are reduced to comply with the regulations, which imply an economic deficit. This corresponds to moving tonnage from the range 1.4-1.6 on the x-axis in Figure 2 to a point corresponding to 1.25 which implies an increase in total cost.

The main objective of the axle load control programme, however, is fulfilled: The reduction in road wear and subsequently the cost of road maintenance is substantial. The savings can mainly be attributed to longer time intervals between rehabilitations/-reconstructions. By dividing the savings on 500 km of road it amounts to 4400 US $ per kilometre of road per year for the 2002 survey and we may add another 10-15 per cent for vehicles in the survey that are not included in the table.

But the flip side of the coin is that trucking cost increases much more, mainly because additional vehicle kilometres are needed for the excessive payload and the net economic result is a substantial cost increase for Zambian economy.

The conclusion is clear:

> **If we only consider savings in road maintenance (road rehabilitation-/reconstruction), strict enforcement of the regulation gives substantial benefits but at the expense of a much bigger increase in transport cost. For the strict enforcement of the regulations to be profitable in social economic terms, the balance has to be made up by other benefits.**

One aspect that should be taken into consideration is what is termed “the cost of public funds”. If “government money” is relatively scarce compared to “private money” the cost and benefits should be weighed depending on the net result for the government sector and the private sector. Weighing of costs and revenues for different sectors is common practice in many countries when public projects are assessed in terms of social costs and benefits. In Norway, for example, the net result for the public sector is weighted by 1.2 while the private sector has a weight of 1.0. However, the examples indicates that a weight of more than 2 will be needed for total cost to decrease and a weight of this magnitude is hardly realistic as an estimate of the “cost of public funds” in Zambia.

Traffic safety is an important issue. In this regard it should be noted that the total vehicle kilometres by trucks will increase by the order of 18 per cent in this example for the 2002 survey. Thus, if the overloaded vehicles are more prone to be involved in traffic accidents than vehicles complying with the regulations, it should be balanced against the added accident risks caused by an 18 per cent increase in vehicle kilometres by VHGVs and possibly also increased average speed for these vehicles.

This example of assessment of cost and benefits presented in tables 14 and 16 raises at least five important questions:

1. There is vehicles going in both direction that have spare capacity with respect to legal payload. Can these vehicles take the excessive payload on the overloaded vehicles?
2. Who pays for the additional cost of trucking?
3. How will the specific origins and destinations of the vehicle trips influence the results?
4. How realistic is to assume an optimum distribution of load on the axles?
5. Is the overloading uneconomic for the hauliers?

4.3.1. Use of spare capacity

Of the semi-trailers surveyed at Livingstone in 2002, 43 per cent were not overloaded with respect to GVM. If these vehicles could take the excessive payload there would – in the example – be no additional trucking cost and the savings in ESAL-kilometres may even be greater with an efficient distribution of the excessive payload on vehicles with spare capacity. First, the spare capacity is not sufficient in terms of pure weight even to take on the excessive payload. Second, while the presence of spare capacity certainly offers a potential for some savings, we should be aware of the following facts:

- Depending on the type of cargo, it will be weight or volume that determines the capacity of a vehicle. Thus, even if vehicles are not loaded to the permitted GVM, their capacity with respect to volume may be fully utilized.
- In order to utilize real spare capacity we need an efficient coordination of truck runs and freight movements in space and time and this will always involve additional costs both in terms of administration and planning and in terms of additional vehicle kilometres. Thus, increasing the utilization of capacity always involves some costs and the practical difficulties should not be overlooked.
- Not all types of cargo can be easily mixed.
- The calculations have not distinguished between tankers and other vehicles. Tankers that carry fuel or chemicals are bound to be empty on the backhaul.

Thus, even if a potential for savings exists, it is next to impossible to say anything more specific about the magnitudes involved. Strict enforcement of the regulations will, however, give truckers and freight owner's stronger economic incentives to utilize available capacity. Overall, the assumption that all excessive payloads need "new" vehicle trips is probably a little too strong.

4.3.2. Who pays for additional trucking cost?

For movement of commodities between origins and destinations within Zambia any increase in transport cost due to enforcement of the regulations will be born by the Zambian economy and, in the end, mainly by the consumers.

A large share of long distance haulage is transport of commodities that are imported or exported. As the Zambian economy are small and has negligible influence on import and export prices, we must expect that increases in transport cost that effects imports and exports will mainly be born by the Zambian economy. The net revenue from exports will decrease and the cif[10] - prices of imports will increase. Some of the increase in transport cost may be "absorbed" as lower profits for foreign firms operating in Zambia, but the magnitude is very uncertain and may depend on the market price of copper.

The trucking industry is competitive and even if much of the trucking is done by foreign operators, the profit in this industry will remain largely unaffected.

The only (sure) net benefit to the Zambian economy comes from transit traffic. For transit traffic the Zambian economy get the savings caused by less road wear, while other countries have to pay for the increase in transport cost.

4.3.3. The impact of origin and destination patterns

In the example above we assumed that the trucks were going between Livingstone and the vicinity of Lusaka, i.e. a distance of 500 kilometres. If average distance (in Zambia) changes, the example will remain unaffected except that all cost will get the same percentage change as the percentage change in average distance.

However, most of the vehicles surveyed are engaged in international traffic which means that actual travel distances are much longer than the leg on Zambian roads. This can make a big difference. While the increase in transport cost due to additional vehicle trips must be calculated for the total length of the vehicle trips, and thus may be grossly underestimated in the example above, the savings to the Zambian economy in terms of less road wear, will only come from the part of the vehicle trips that uses the Zambian road network. The surrounding countries will get some of the total benefits because their roads are also affected.

But if we look strictly at the consequences for the Zambian economy, the fact that import and exports by road have to pass through other countries implies that Zambian economy gets only part of the total benefits, but has to take on the full increase in transport cost.

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[10] CIF is an abbrivation for "Cost, Insurance, Freight" , i.e. the import price of goods including the cost of freight and insurance.

Consequently, when international traffic is involved, calculating transport cost only on the leg of the trip inside Zambia will grossly underestimate the real increase in transport cost.

The dispersion of origins and destinations both between countries and within countries for freight that passes a specific point in the road system is also a major impediment for efficient utilization of truck capacity on the Zambian road network.

4.3.4. Distribution of load on axles

In the example above we assume that vehicles that are overloaded on one or more axles, but stay within the permitted GVM, can redistribute the load optimally on the axles. The savings in ESALs from this assumption constitutes 10 and 18 per cent of total savings in ESALs for the two directions respectively. An even distribution of the load is only easy to accomplish if the payload consists of a homogeneous commodity that is perfectly divisible. For heavy machinery and some other commodities, it can be nearly impossible to distribute the load evenly on the axles and avoid overload on one or more axles. Thus, the estimates of the savings in ESALs from redistribution of the loads are on the optimistic side. Nevertheless, enforcing the axle load regulations will tend to make truckers more aware of the distribution of load on the vehicles.

4.3.5. “Uneconomic overloading“

It is possible to imagine that truckers do not know their own best interest.
If the cost of taking an additional tonne of payload in terms of fuel consumption and wear and tear on vehicle parts are greater than the revenue from an additional tonne of payload, the additional payload is uneconomic to take.
But if a trucker underestimates the marginal cost of an additional tonne of payload, he may take the payload anyway. If this is a prevalent phenomenon, enforcing regulations may – within certain limits – decrease the trucking cost per tonne-kilometre because some truckers do not behave in their own best interest.

We can not totally disregard this issue, but the logic is troublesome in a longer perspective. Trucking is a competitive industry and operators that on a regular basis underestimate their real cost and accept too much payload will loose money in the longer run and will soon be out of business because they can not compete with the rates that can be offered by truckers that are aware of the most economic load for different types of vehicles.

Thus, at any time we may observe some uneconomic loading of vehicles due to ignorance on part of the truckers, but this should not persist at an <u>important</u> long term phenomenon in a competitive industry.

To conclude on the questions posed above:

> There are some aspects that are not taken properly care of in the example. There is a certain potential for better utilization of the capacity of vehicles that are not loaded to the limit for GVM, but it is impossible to make an assessment of this potential and associated costs based on the information available. On the other hand – for vehicles engaged in international transport we may grossly underestimate the impact on transport cost by only focusing only on distances driven in Zambia. Even if a large share of the international transport is carried out by foreign trucking firms, the Zambian economy must bear the major share of any increase in the transport costs of imports and exports. There might be a moderate reduction in vehicle operating per vehicle kilometre because some truckers - out of ignorance – load their vehicles above the most profitable payload, but it is difficult to see how this can persist in the longer run in a competitive industry.

An accurate total assessment of total costs and benefits are difficult because the surveys don’t contain information on the origins and destinations of the vehicle trips and because expanding the surveys to annual figures will involve a lot of double and triple counting if we try to assign a realistic average distance for vehicle trips for the vehicles at each survey site. Thus, while the choice of survey sites is reasonable when the objective is to get information on the loads on different sections of the road network, the choice of sites and the lack of origin-destination information pose a problem when impacts on transport cost shall be estimated.

We will therefore recommend that future surveys record the origin and destination of the trips for the surveyed vehicles and also the type of goods they carry.

5. Overall results - Total reduction in ESAL-kilometres and road wear cost.

The BSL reports survey results for 10 survey sites carried out in the period 2002-2004. The results are for specific points in the road system, but the traffic at these points may be representative for certain links in the road system. Thus, the length of these links can be multiplied by ESAL-figures calculated to arrive at an estimate of ESAL-kilometres and savings in ESAL-kilometres for these links with full compliance with the new regulations. However, it has not been possible to make any correction for seasonal variations in traffic volumes and loads.

On an annual basis there should also be approximate directional balance for the different vehicle categories. This is not the case for most of the survey sites and is not to be expected for a one week survey.

There is no way to guarantee that results on the different survey sites are representative for an average week in a statistical sense without extensive traffic counts over the year that can form the bases for construction of weights to be used for the different sites. On the other hand, with 10 survey sites some of the statistical variations will tend to even out in the aggregate results.

The calculation of ESALs, excessive payload, "new vehicles" and savings in ESALs has been done for all survey sites for semi-trailers with the following configurations:

1.22-222
1.22-22-22
1.22-22-222
1.22-222-22
1.22-222-222

These vehicle categories produce approximately 2/3 of the ESALs at the survey sites and together with the remaining VHGV's (with a multitude of different axle configurations) they produce nearly all the excessive payload. The results for ESALs and estimated ESAL-kilometres for these 5 vehicle types are shown in Table 17.

Table 17: Results for survey sites assigned to associated road links – 5 semi-trailer configurations. ESALs and estimated annual ESAL-kilometres and the impact of compliance with regulations.

			One week survey		*Annual ESAL-km*	
	Road link:	**Length (km)**	**ESALs**	**Δ ESALs**	**(Million)**	**Δ Esal-km (Million)**
A	Livingstone- Mazubuku	347	4855	-1940	87.6	-35.0
B	Mazubuku – Kafue	80	3517	-1547	14.6	-6.4
C	Chirundu-Kafue	92	6791	-2037	32.5	-9.7
D = B+C	Kafue-Lusaka	44	10308	-3583	23.6	-8.2
E	Nakonde-Mpika	402	1013	-626	21.2	-13.1
F	Mpika – Serenje	233	1863	-1148	22.6	-13.9
G = F-E	Mbala-Mpika (M1)	371	850	-523	16.4	-10.1
H	Serenje - Kapiri Mposhi	195	1934	-1181	19.6	-12.0
I = H-G	Mansa-Serenje	282	71	-33	1.0	-0.5
J	Kapiri Mposhi-Lusaka	133	8340	-4955	57.7	-34.3
K	Chipata-Lusaka	563	2074	-1157	60.7	-33.9
L	Ndala-Kapiri Mposhi	115	6782	-2856	40.6	-17.1
M	Mongu-Lusaka (M9)	593	1511	-783	46.6	-24.1
Sum semi-trailers (5)		3450	49910	-22370	444.7	-218.3

With full compliance with the regulations, the ESALs at the survey sites will be reduced by 45 per cent while estimated ESAL-kilometres on the road network are reduced by 49 per cent.

Based on the excessive payload according to regulations, Table 18 gives the estimate of additional vehicle kilometres. The assumption is that excessive payload will be taken by semi-trailers with configuration 1.22-222 taking 36 tonnes of payload. The number of vehicles is taken as the number of vehicles needed in the direction with the highest tonnage of excessive payload. The vehicle kilometres are calculated also for the backhaul. The ESALs produced by these vehicles is included in the estimates of reduction in ESAL-kilometres.

The underlying assumption is that the additional vehicle trips added to an origin – destination matrix of vehicle trips will imply additional vehicle-kilometres on the road links as calculated in the table.

Thus, in order to take the excessive payload of these 5 vehicle types, table 17 shows that 560 additional vehicles are needed at the survey sites and on an annual basis these additional vehicle trips will produce an estimated 9.9 million vehicle kilometres per year with 'semis' having axle configuration 1.22-222.

For these road links and vehicle types strict enforcement of the regulations will give an annual saving in road maintenance, mainly for rehabilitation/reconstruction, of the order:

218.3 Mill ESAL-kilometres * 0.015 US $/ESAL-km = 3.27 Mill US $ per year.

Table 18. Vehicles and annual vehicle kilometres needed for excessive payload.

	Road link:	***"New vehicles" at survey sites-one week***	***Veh.kms/y (Million)***
A	Livingstone- Mazubuku	56.8	2.05
B	Mazubuku – Kafue	50.4	0.42
C	Chirundu-Kafue	61.0	0.58
D = B+C	Kafue-Lusaka	111.4	0.51
E	Nakonde-Mpika	19.7	0.82
F	Mpika – Serenje	22.9	0.55
G = F-E	Mbala-Mpika (M1)	3.2	0.12
H	Serenje - Kapiri Mposhi	23.1	0.47
I = H-G	Mansa-Serenje	0.2	0.01
J	Kapiri Mposhi-Lusaka	98.0	1.36
K	Chipata-Lusaka	22.7	1.33
L	Ndala-Kapiri Mposhi	78.1	0.93
M	Mongu-Lusaka	11.8	0.73
Sum semi-trailers (5)		559.3	9.9

The additional transport cost (on the Zambian roads) is of the order:

9.9 Million Vehicle-kilometres * 1.25 US $/Vkm = 12.4 Mill US $

Here we have made no correction for transit traffic, the increased costs of which are not paid for by the Zambian economy. On the other hand, no allowances have been made for the transport cost outside of Zambia for exports and imports. The consequences of this omission are much greater than making no deduction for transit traffic.

How should these figures be expanded to cover the whole road network and all types of vehicles?

First, to allow for the remaining vehicle types at the survey sites, both the savings in maintenance cost and the additional trucking cost should be multiplied by a factor between 1.2 and 1.3.

If we use 1.3, the savings in maintenance cost per kilometre of road amounts to approximately 1230 US $ per year for the road links in Table 17 that has a total length of 3450 kilometres. The trunk road network is Zambia has a total length of approximately 3100 kilometres and the main roads network is approximately 3700 kilometres. If we look at these two road classes together there is an additional (3100 + 3700 – 3450) = 3350 kilometres of road affected by enforcement of the regulations. The average volume of traffic (and number of overloaded vehicles) per kilometre on these additional 3350 kilometres are much lower than for the links included in Tables 17 and 18. The savings in maintenance costs will consequently also be much lower.

If we assume that the savings per kilometre amounts to 20 per cent of the savings for the road links included in Tables 17 and 18 that carries the bulk of the heavy traffic, we arrive at an estimate of total savings for the remaining road network of: 3350 km*1230 US $/km *0.2 = 0.82 Mill US $ and thus bringing the estimate of total savings in road maintenance cost to:

(0.82 + 3.27) Mill US $ = 4.09 Mill US $.

We consider this estimate to be on the optimistic side, especially because the enforcement of the regulations in the longer run will reduce the use of vehicles with 7+ axles and increase the use of vehicles with 6 that will produce more ESAL-kilometres for the same freight movements. This effect is further demonstrated in Table 20.

Discounted over 15 years at an interest rate of 6 per cent, the present value of this annual saving is 41 Mill US $.

The conclusion from this economic assessment is very clear:

> **An efficient enforcement of the present regulations will reduce the needed annual expenditures on road maintenance by the order of 4 Mill US $, but will increase transport cost by – at least – 3 times this amount.**

The most critical aspect of the regulations is actually the maximum GVM. As an example of the implications we have run the Mazabuka survey of 2004 for the 5 vehicle categories used above and assume a permitted GVM for 7+ axle vehicles of 70 tonnes instead of 56 tonnes, while retaining the axel-load regulations. For vehicles with configuration 1.22-

222 and 1.22-22-22 the new axle-load regulations including 5 per cent allowance will in any case determine the maximum GVM and 52 and 64 tonnes are therefore used as maximum permissible GVM for these vehicle types respectively.

In Table 20 we have estimated the impact of enforcing the present regulations on two different assumptions. Alternative P is based on the assumptions previously used that excessive payload is removed and assigned to vehicles with configuration 1.22-222. In addition, the payload on vehicles that are overloaded only axles is assumed to be redistributed evenly.

The payload allowed by different regulations of GVM will typically look like Table 19 although there will be some variations with respect to tare weight. At 70 tonnes allowed GVM the payload for the two first configurations will be constrained by the allowed axle loads + 5 per cent allowance, while the configurations with 8 axles will exactly match 70 tonnes with 5 per cent allowance. Only for 1.22-222-222 will 70 tonnes be an effective constraint on payload. Thus, with the present regulations there will be a maximum of 3 tonnes of payload to cover the additional cost of adding a trailer.

Alternative P* is therefore based on the assumption that the payload on 8 and 9 axle trucks are transferred to 1.22-22-22 which is a more realistic assumption for all but very short term adaptations to the regulations for GVM.

Table 19: Payload and allowed GVM

Configuration	*Tare weight*	*Payload @ 50/56 tonnes GVM*		*Payload @ 70 tonnes GVM*	
		Tonnes	Effective constraint	Tonnes	Effective constraint
1.22-222	14	36	GVM	38	Axleload
1.22-22-22	20	36	GVM	45	Axleload
1.22-22-222	22	34	GVM	48	Both
1.22-222-22	22	34	GVM	48	Both
1.22-222-222	24	32	GVM	46	GVM

The figures in Table 20 shows that the P alternative gives a percentage reduction in ESALs of 38.8 per cent, while the more realistic alternative (P*) only gives 31.2 per cent. Both alternatives give a considerable increase in “new vehicles” that are needed for the excessive payload. However, the tested alternative (A) shows that the GVM regulation is the main reason for the high number of “new vehicles” while the contribution of the GVM regulation to the reduction in ESALs is rather moderate since the reduction with 70 tonnes GVM is still as much as 27.5 per cent.

> *Thus from the point of view of total combined cost for road wear and freight transport it is the regulation of GVM that has the strongest impact. Allowing 70 tonnes GVM instead of 50/56 tonnes for these vehicles and enforcing present axle*

> *load regulation will give 18 per cent more ESALs when compared to P and only 5 per cent when compared to the more realistic alternative P*.*

This is not to say that 70 tonnes of GVM is the correct regulation to apply, only to illustrate the consequences of having GVM as the efficient constraint on payload rather than the axle load regulations.

Table 20: Test of alternative GVM – regulation of 70 tonnes (A) and possible effects of changes in vehicle types (P*)

		1.22-222		***1.22-22-22***		***1.22-22-222***		***1.22-222-22***		***1.22-222-222***		***Total 5 'semis'***		
		P	***A***	***P***	***A***	***P***	***A***	***P***	***A***	***P***	***A***	***P***	***P****	***A***
Permitted GVM	***tonnes***	***50***	***52***	***56***	***64***	***56***	***70***	***56***	***70***	***56***	***70***	***50/56***	***50/56***	***70***
Legal ESALs		***9.7***	***11***	***9.2***	***16.2***	***7.2***	***15.5***	***7.2***	***15.5***	***4.2***	***12***	*****	*****	*****
Legal ESALs on new veh		***9.7***	***11***	***9.7***	***16.2***	***9.7***	***15.5***	***9.7***	***15.5***	***9.7***	***15.5***	*****	*****	*****
Payload on new veh.	***tonnes***	***36***	***38***	***36***	***48***	***36***	***52.5***	***36***	***52.5***	***36***	***52.5***	*****	*****	*****
Overload on GVM	**# vehicles**	96	79	34	15	22	10	24	12	89	77	265	265	193
Excess load	**tonnes**	554.8	381.0	256.0	40.6	313.8	75.2	335.5	78.4	2028.6	839.8	3488.7	3488.7	1415.0
ESALs survey		1713.3	1511.7	637.1	332.0	436.7	278.7	480.6	320.0	1796.6	1679.79	5064.3	5064.3	4122.1
ESALs without overload		931.2	869.0	312.8	243.0	158.4	155.0	172.8	186.0	364.9	924	1940.1	2486.0	2377.0
"New vehicles"		13.1	8.7	6.9	0.9	7.5	1.4	7.5	1.4	28.5	8.34	63.5	59.6	20.7
ESALs on new veh.		149.5	110.3	69.0	14.0	84.6	22.2	90.4	23.2	546.6	191.95	940.0	841.6	361.6
Overload on axles only	**# vehicles**	39.0	56.0	2.0	18.0	0.0	8.0	0.0	9	0.0	3	41.0	41.0	94.0
ESALs survey		397.0	598.7	13.1	280.1	0.0	115.2	0.0	130.2	0.0	38.8	410.1	410.1	1162.9
ESALs load even		303.2	476.6	7.9	228.1	0.0	93.7	0.0	101.4	0.0	27.5	311.1	311.1	927.3
No overload	**# vehicles**	122.0	122.0	23.0	26.0	11.0	15.0	20.0	23.0	10.0	19.0	186.0	186.0	205.0
ESALs on legal		254.9	254.9	80.6	118.7	18.3	61.1	41.5	71.9	13.0	91.0	408.1	408.1	597.5
Total ESALs with compliance		1638.7	1710.7	470.2	603.7	261.2	332.0	304.7	382.5	924.5	1234.4	3599.3	4046.8	4263.4
Δ ESALs with compliance		-726.5	-654.5	-260.5	-127.0	-193.8	-122.9	-217.4	-139.6	-885.1	-575.09	-2283.2	-1835.7	-1619.1
Percentage change		-30.7	-27.7	-35.7	-17.4	-42.6	-27.0	-41.6	-26.7	-48.9	-31.78	-38.8	-31.2	-27.5

P=present regulations **P*=present regulations with adjusted vehicle fleet** **A=Alternative tested**

6. Concluding remarks

In this study we have evaluated the economic impacts of axle load control programme for Zambian economy. The focus has been on the impacts of enforcing the axle load control of heavy vehicles and not the whole programme per se. In this respect, it worth noting that programme itself is on schedule and if completed will have a much wider positive impact, however not measurable in monetary units. Impacts not measurable in monetary terms include non-measurable impacts include: (i) The programme can contribute to a more general awareness of the corruption problem and set an example in this respect, (ii) Information about the programme and its objectives can improve the general awareness of truckers when it comes to problems caused by overloading, (iv) The programme will promote fair and efficient competition in the trucking industry by not given a competitive advantage to operators that do not comply with the rules and regulations pertaining to loading of vehicles, (v) Depending on the level on non-compliance with the regulations, the fines collected from overloaded vehicles may generate revenues exceeding the cost of operating the programme and thus provide additional funding for road maintenance. However, if the programme is efficient, the rate of compliance will – in the longer run – be high and the revenue consequently low.

The main impacts measurable in monetary terms of enforcing the axle load control of heavy vehicles are found to be:

- Reduction in maintenance costs to the government due to reduction in overloading
- Increase in transport costs to transporters because the same payload has to be transported by more trucks.

Assuming an efficient enforcement of the present regulations for axle loads and GVM, the axle load programme will lead to a considerable reduction in road maintenance cost of about 4 Mill US$ annually. This will be a benefit, especially to the government of Zambia. However, the estimated increase in transport costs due to additional vehicle kilometres is about 12 Mill US$ annually; 3 times the savings in the maintenance costs. A strict enforcement of the regulations does thus lead to a net increase in costs of about 8 mill US$ annually. The main reason for this large “deficit” is the GVM regulation. The analysis suggests that even a higher GVM limit than 56 tonnes would reduce the ESAL-kilometres considerably, and would imply a lower increase in transport cost than the 56 tonne limit. On the other hand, the new regulations of GVM are an improvement compared to the old regulations and thus a move in the right direction.

Given that there are several positive impacts of the programme, the difficult question is whether such impacts are so positive that they would counteract the net cost of 8 million US $ a year. Without replying directly to this question above- it should stated that the axle load programme has some considerable positive impacts. The estimated increase in costs has nothing to do with the efficiency of the axle load programme. There is no reason to question the efficiency of the programme. The benchmark studies have already shown a considerable reduction in over loading. The net increase in costs is a direct consequence of the regulations enforced.

While the rationale for regulation of maximum axle loads is related to road wear and the cost of road maintenance, the rational for a maximum permitted GVM is difficult to demonstrate without extensive knowledge about the strength of long bridges. The Zambian road authorities have already started work on registration of the bridges. Traffic safety has been claimed as a reason for regulating GVM, but the issue is ambiguous.

Zambia is a part of the SADCC where there is an agreement of 56 tonnes as maximum GVM and a maximum load on a dual wheel single axle of 10 tonnes in short term. The enforcement of the regulations in Zambia is thus an implementation of the agreement. SADCC has a long term perspective of increasing the limit to 13 tonnes for a standard axle, but there is not a corresponding long term objective for GVM. However, if axle load restrictions are moved in the direction of the long term objective, GVM regulations must follow suit. The is little to be gained from increasing permitted axle loads, if GVM regulations remains at present level and is the effective constraint on payload for the trucking industry, An examination of optimum GVM regulation is beyond the scope of this study. What the study indicates is that the move from 55 to 56 tonnes has been a move in the right direction from a national economic perspective and a further increase is beneficial if the strength of the bridges can allow for it.

References

Institute of Transport Economics and Carl Bro International A/S (1993): *"Axle Load Study for Southern Africa – Final Report"*. TØI-report 180/1993

Ministry of Works and Supply, Roads Department, Zambia (2005), *Axle Load baseline study 2002 -2004 Final Report*

Ministry of Works and Supply, Roads Department, Zambia (2006), *Axle Load Benchmark Survey*

Morosiuk, G. and Riley, M (2004).: *Modelling Road Deterioration and Work Effects,* HDM-4, Volume 6. (World Road Association (PIARC) and The World Bank, Washington D.C., US)

Small, K.A., Winston C. and Evans C.A. (1989): "Road Work", The Brookings Institution, Washington D.C.

Appendix – Road Map of Zambia