Transport Research Foundation

New Thoughts on a Pragmatic Structure for Managing Roads

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Lecture delivered
21 January 2004
Council Room, Institute of Mechanical Engineers

The Fellowship Chairman, Professor R M Kimber, in the Chair

First Published 2005
ISBN 1-84608-828-3

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Martin Snaith's distinguished career has encompassed a great deal of work on highway design and maintenance over a wide range of applications. The subject is important because the resource costs needed to build and maintain road and transport systems are so high and because of the sheer impact that transport and roads in particular have on the economies of whole nations. From an early stage Martin took a close interest in materials issues for roads in developing as well as developed countries, and his earlier experience included work on national road design and maintenance in Kenya. Over the years his research and teaching have been very influential and, in particular, he has had very great success building the MSc Course in Highway Engineering at Birmingham which has had a very considerable impact on the profession over the years. At the University Martin served as Pro-Vice Chancellor for many years. He is now Emeritus Professor at Birmingham and Erskine Fellow at the University of Canterbury, New Zealand.

Abstract

The lecture provides a short history of the development of road pavement management systems (PMS) from the late 1960s to the present day and ends by highlighting issues that require further research. The close link between economic progress and a good road transport system was instrumental in driving the early development of PMS, especially systems for use in the poorer countries of the world where it is vital that investments in the road transport system are chosen so as to provide the highest economic returns. In the early days there was insufficient knowledge about all of the components required to produce a complete working system; for example, not enough was known about the effects of different maintenance strategies on road performance, or about the interaction between the condition of a road surface and the cost of operating vehicles upon it. By the mid 1970s, largely as a result of initiatives by the World Bank and the UK's Department for Economic Development, sufficient research had been done to provide the knowledge required to create prototype systems. The lecture shows how such systems have evolved to assist with strategic level (long-term) decision making, network level planning (to optimise the rolling annual investment over the (whole) lives of the roads), and individual project level design. The importance of an integrated approach to project and network level planning is emphasised. The problems of dealing with data are addressed and a practical step-wise method is advocated which will reduce the costs of data collection. Multi-criteria analysis is introduced for taking non-monetary benefits into account and the challenge of incorporating asset valuation into the decision process is highlighted. Several case studies are used throughout the lecture to illustrate the points raised.

New Thoughts on a Pragmatic Structure for Managing Roads

Professor Martin Snaith

The University of Birmingham

Chair, fellow Fellows and our guests, thank you for coming; it's a pleasure to be here. What I am going to speak about first is what I regard as the basics of generic systems for managing highway networks. Then I'll come on to real systems—to how we are trying to put those academic ideas together to apply to real systems in various places around the world. I hope this will therefore give us a pragmatic structure for managing highways.

Roads all seem to have different histories, and traits. We deal with roads that have, in some cases, been there for 2000 years. We also look at a multiplicity of different types of roads. We also deal with rigid pavements and bituminous pavements, and our networks are made up of elements of both of those types of structure.

Much of my work has been for developing countries and, when I speak about managing a network, I am thinking in terms of those countries. Small amounts of money are available to encourage development or, if you wish, to reduce poverty. Making this work available is central to what we have been trying to do at Birmingham University and at TRL. The pressing need for methods of road asset management really comes from those countries where there simply isn't enough money to go around.

If I am in a wealthy country and I sit with my gin and tonic in my hand and somebody comes and jogs my elbow, I shall still have plenty remaining in the glass to drink, so the effect on me is not too great. But if, on the other hand I'm in some poor country in the middle of sub-Saharan Africa where they have little or no money at all and somebody jogs my elbow, there is so little there and once the drink has gone there's nothing left. That's different altogether. So being careful with resources is imperative.

TASKS OF ROAD NETWORK

To encourage development

WHILST

using a small portion of the G.N.P

Figure 1: The task

It was that fact that drove the World Bank and the Aid Agencies, particularly what was then the Overseas Development Administration, to start working very hard on road maintenance and to direct me, amongst others, to look at it and the management of the asset.

Figure 2 shows data from the World Bank. There is a correlation between the wealth of a county and the amount of money being spent on road maintenance. The wealthy countries spend a lot of money on maintenance and the poor countries do not. Which comes first? The question is 'is it chicken or egg?' I believe that a poor country has to spend more on road maintenance to drag itself up to generate more wealth. I believe, for example, that if the road network is poor then goods cannot be got to market cheaply and competitively on the world scene and therefore money will not enter into the economy. Similarly doctors, nurses and teachers will not get to where they can actually help people and educate them so as to get them to the stage where they are able to contribute to the economy. So it is a vital job for us as road engineers to develop these systems. 25% of the world is living below the poverty line—and by poverty line I mean less than $1 per day. That is absolutely frightening.

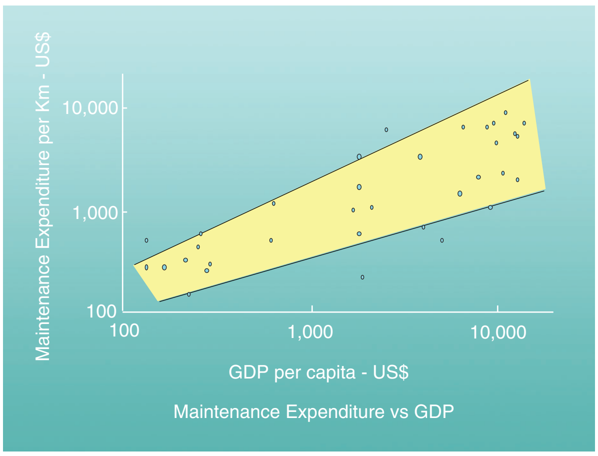

Figure 2: Correlation between GDP and expenditure on road maintenance

The purpose of systems is well expressed in these words from the Road Transport Association of Canada (Figure 3).

PURPOSE OF A SYSTEM - R.T.A.C

"TO ACHIEVE THE BEST VALUE POSSIBLE FOR AVAILABLE PUBLIC FUNDS AND TO PROVIDE SAFE, COMFORTABLE AND ECONOMIC TRANSPORTATION"

Figure 3: The purpose of road management systems

I remember a lecture about 25-30 years ago given by our old friends Professors R Hudson and R Hass who were talking about *project level maintenance* and *network level maintenance.* This has proved extremely important over the years. I thought that this evening I would see if I could elucidate these concepts as they have developed.

Let's look at network level maintenance. *Network level maintenance* examines the entire road network and works at government level. It represents the overall behavioural pattern of a network in terms of how much money it consumes and how much money it saves for the economy. So we are going to be using economics to help make decisions which will hopefully define a condition towards which we strive. Then in five or ten years time we might actually achieve a reasonable standard for the network as a whole.

Figure 4 shows the sort of thing that network level maintenance will do. It will allow a target to be set, in this case the condition of surface roughness of the roads in the network. Over a few years, if $20m were spent this will finally achieve the lowest value of roughness shown by the bottom curve, whereas by spending $10m the road network will get steadily worse (upper curve). These are the sorts of questions to be examined. For network level maintenance we look at the long term condition of the network as a whole in relation to the amount of spend.

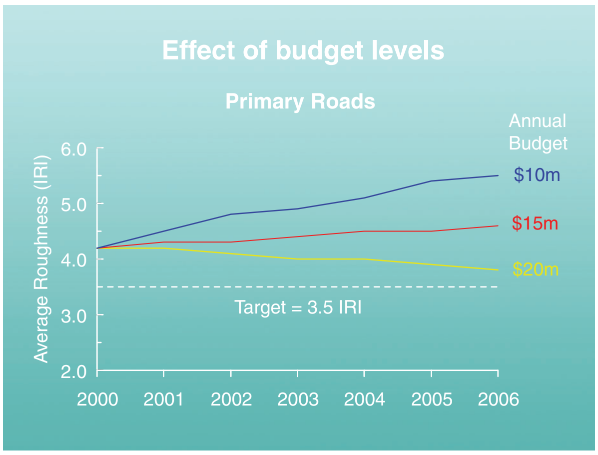

Figure 4: The effect of budget levels on the condition of the road network

Project level maintenance is much more about engineering. Here we look at specific sections of road. I feel much more comfortable with this because I am a civil engineer, since if the road is cracked, I can see that there is something wrong with it and if it is necessary, I want to fix it. Engineering models can be put together, and decisions made at local level. We then hope to be able to forecast what the road condition will be at some future time e.g. in ten years. The condition at the end of ten years will, we hope, tally with what we had forecast. Thus the approach is to examine the road to find out what is wrong so that it can be fixed properly and do the job for which it was designed.

In practice the two approaches—*network level maintenance* and *project level maintenance*—must come together (Figure 5). Lots of little projects—lots of little road sections—will contribute to one big network. Too often around the world these two logic streams have been kept apart. The thrust now is to bring them together so that not only does the budget drive what the engineers do but the knowledge of the engineers also drives the budget. This moves away from the familiar approach of just using last year's budget plus inflation.

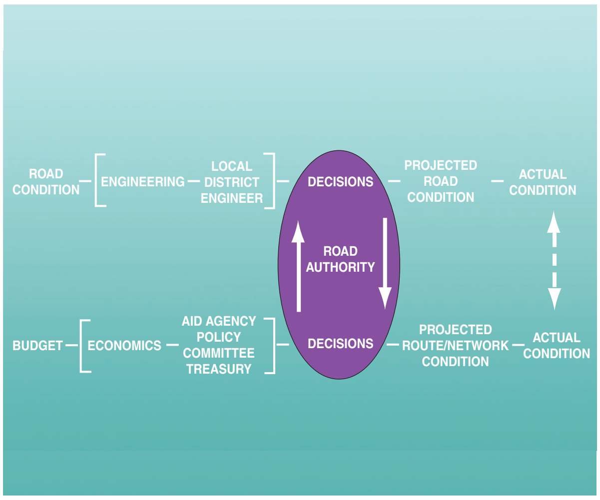

Figure 5: Project and network level management

The task is to unify. I call this *project-to-network interfacing*. What I am now going describe is a generic system for trying to achieve this. But remember always that it is all quite simply about getting the work done at the right price and in the right place.

Let us now concentrate on the central region of Figure 5 where the project level and the network level should come together. Let me expand this part of the diagram and turn it through 90 degrees to end up with something which looks like Figure 6.

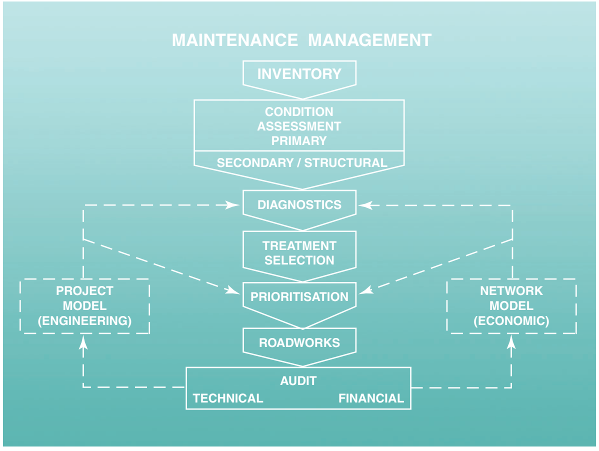

Figure 6: Maintenance management

On the left is project level modelling, which is quite simple, and on the right is network level modelling, and this is also quite simple. The difficult thing is in bringing the whole thing together in the '*project to network interface*'. Let's work our way through this interface and see if we can learn anything along the route.

The first thing is the inventory. Roads need to be registered to list what exists. It is extraordinary that around the world authorities do not know what they have in the way of road networks. Moreover, if one asks 'do you know what percentage of roads are bitumen, what percentage are flexible and what percentage are mixed?'—very often this is not known either. The network must first be registered. It is a fairly lengthy process. When we register it we will need to do so in such a manner that it is understandable to a computer—so that every section of road has a unique reference number.

Markers alongside the road can be used, as shown in Figure 7 from Malaysia. These can be in different formats; they can be linked to telegraph poles for example. The obvious question is 'why don't they use GPS?'. But GPS, as some of you will know, doesn't always link directly to what is actually going on on the ground. No doubt it will come in at some stage, but I do not think it is ready yet.

The next thing is to look at the road condition itself. We might have rutting as can be seen in Figure 8. Rutting is, curiously, a very difficult thing to measure. Everybody thinks that rutting can be seen just by driving along the road. Figure 8 illustrates how clearly one can see rutting wherever water runs down the ruts (in this case the lubricating water from cutting a trench). This road is very severely rutted. But if one

Figure 7: Inventory. Identifying and registering the components of a road network

Figure 8: Ruts in the wheel paths

looks further up along the road it is very difficult to see that it is rutted at all. It therefore has to be measured; we must get good hard data—objective data—on the road condition.

Cracking is very important. We have to bear in mind that (for the sake of argument) probably 90% of the damage on roads as a whole actually comes from the environment, not from traffic. Traffic will exacerbate it afterwards, but most of the damage is caused by the environment and we also have to bear this in mind when we are modelling the behaviour of roads.

Finally there are road roughness, skid resistance and surface texture. If a road is very slick, in rainy conditions it would be dangerous; and high roughness will mean that vehicle operating costs are unacceptable.

Collecting data of these types is expensive (Figure 9).

Collecting this information is demanding since there is a trade-off against the maintenance spend itself. For example, if (say) 2% of the whole budget were allocated to data collection, then one couldn't afford to do detailed investigations everywhere at the sort of prices in Figure 9. So something else is therefore needed.

Figure 9: The cost of data collection

One thing that may seem attractive is sampling; but sampling I believe is actually not very good. Unless it is very carefully done, it can be horribly misleading. Therefore a way is needed in which we can directly measure the condition of the roads reasonably cheaply. How can it be done? The answer is what I call 'step data collection' *over the whole of the netw*ork, Figure 10.

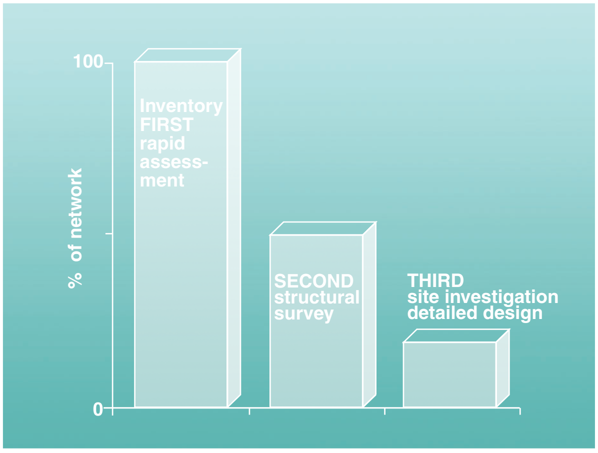

Figure 10: 'Step' data collection for network

Survey teams are sent out to do a preliminary (first) assessment in which they measure one parameter (or, if possible, more than one) over the whole network. This should be done relatively quickly and cheaply; but it might not be done very well to begin with. In the past we would have used a small survey team such as that shown in Figure 11 but these days we use an automated survey procedure using an equipped vehicle (Figure 12) such as TRACS (Traffic Speed Condition Survey) or a Laser RST (Road Surface Tester).

It is very important to check the data before entering them into the database. Throughout the world, unfortunately, we often find that this has not been done with the result that some data turn out to be of very poor quality. Furthermore we often find that bad habits have continued for many years. I cannot emphasise enough the importance of checking data properly.

Figure 11: Survey team for preliminary assessment

Figure 12: The highspeed Road Surface Tester

The data are then stored in a database which is interrogated to identify sections or areas of road where there is likely to be a problem.

The next step (the second stage) is to survey these areas in more detail and this should include, for example, deflectometer measurements to evaluate the structural condition of the pavement (Figure 13). These data are also checked and stored in the database which is then examined again to identify those areas where the problems are most serious.

Figure 13: A Falling Weight Deflectometer

Finally, knowing what the budget is likely to be, we can identify, approximately, those areas of road that we can afford to repair or to treat. We then send out our survey team once again (the third stage), this time to collect sufficiently detailed data to verify exactly what is wrong with the road and to design the repair works. Core samples might be taken or trenches dug across the road (Figure 14). Notice that we do not use destructive methods of testing until we reach this final stage when we are fairly sure that there is really something wrong.

Figure 14: Cutting cores for detailed investigation

An early example of this process is some work that was done on the M1 in Northern Ireland some years ago. Indeed, a number of the ideas that I have been using in my work overseas were first developed whilst working with the road authorities in Northern Ireland. I think the medical term 'diagnostics' describes what we are trying to do and this example is a good one because it is very clear.

During the preliminary screening, stretches of road were marked out to show where there were problems.

A second more detailed survey was carried out of the problem areas to measure the rutting, cracking, ride quality and deflection. The road was divided into micro-sections of 20m length and then, for each section, values of '0', '+', or '-' were assigned for 'satisfactory', 'critical' and 'unacceptable' respectively. An example is shown in Figure 15 for the section between chainages 480 and 500. At this chainage we can see that there are two critical parameters, cracking and riding quality, and the computer tells us that the severity code is 8 or 9. This means that we cannot be quite sure what needs to be done, and so a trial pit is needed to find out what is really going wrong.

The computer sifts through all of these data in an objective manner to assign severity codes to every section to help determine what should be done with the pavement (Figure 16).

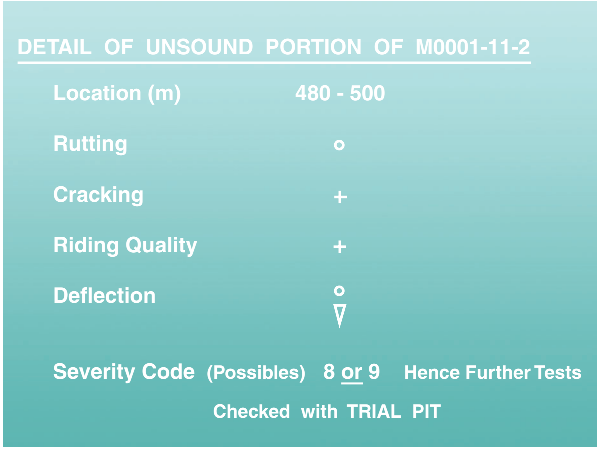

Figure 15: Example of the condition of a micro section

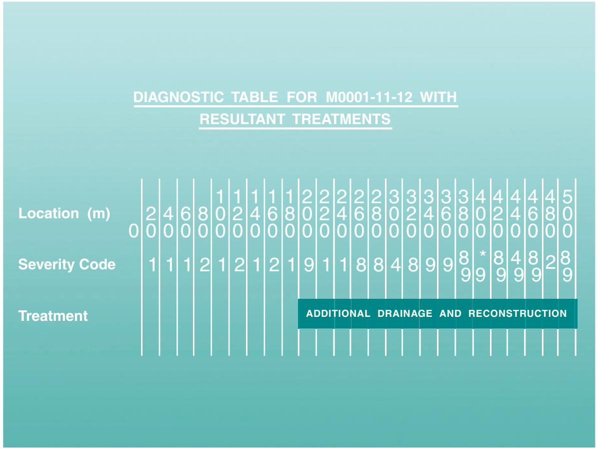

Figure 16: Diagnostic table for successive microsections

The next stage is the tertiary survey, directed by what the system has told us so far. If all of the micro sections are examined from the start (Figure 16) we can clearly see, first, a block that is in good condition (chainage 0 to 180). Thus the computer has identified a length of road where all the parameters that we were measuring were satisfactory and, therefore, where there was nothing wrong. This may sound rather trivial but it saved a lot of time because an engineer did not need to do it by hand. We can then see a block which is a little doubtful (chainages 200 to 240) and then a region (chainages 260 to 500) with a problem where the micro-sections are, in order *bad, bad, OK, bad, bad* and lots more *bads.*

A trial pit was dug in this area and we found a lot of water at the bottom. We also found that, in the wheel-track, there had been a lot of pumping of clay fines up into the granular material (at that time, in Northern Ireland, thick layers of granular materials were being used in motorway construction). The clay had weakened the mechanical interlock between the granular particles resulting in severe rutting in the wheel-tracks. The decision was made to reconstruct and to put in new drainage as soon as possible, as noted in Figure 16. Incidentally a geotextile fabric was also placed between the subgrade and sub-base (to keep the two separate in the future). This is a good example of the sort of knowledge and planning that can be built into a management system if one copies what a good engineer would do.

This is an example of collecting data in a step manner, applying diagnostics through a knowledge base and being directed towards the right kind of treatment through the use of a system. Once the decision process has been programmed properly it can be applied to the whole of the network, not just on a particular project such as this 500m stretch.

As another example, Figure 17 shows an elementary decision algorithm, 'if the deflection is greater than y mm, then apply an overlay of z mm'. Whilst it is elementary, it makes the point; and it leads on to another, namely that we have to be careful not to oversimplify. The reason is that large sums of money could be wasted because it often happens that whilst deflections may be high, structural integrity may still be adequate and therefore overlaying will be unnecessary. In practice the algorithms that we use today are a lot more complex.

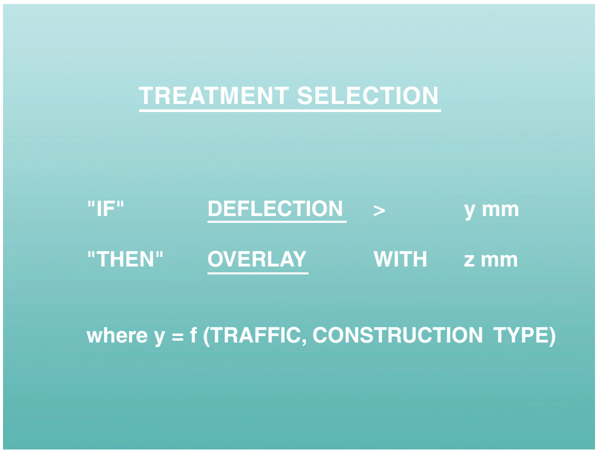

Figure 17: Simple decision algorithm for overlying a road

Having carried out the initial designs we next have to consider combining some of the micro-sections together and ignoring a change in design (for example) over a short section in order to optimise the project in economic terms. This can be done by common sense or, again, it can be programmed into the computer. For example (Figure 18), if we had a potential project on the left and another project on the right, both of a fairly substantial nature (for example, a thick overlay, but in between something simpler was required (say a surface dressing), should we apply the overlay throughout or would we leave them as individual projects?

This question could be answered within the system. For example, a simple algorithm that could be used might be that 'if the mobilisation costs that would be saved if the overlay is continued through the middle section is greater than the marginal increase in treatment costs, then combine the projects into one overlay project' (Figure 19). To summarise, if an algorithm can be written to reflect what the engineer would normally do, then the computer can be programmed to do the work for us.

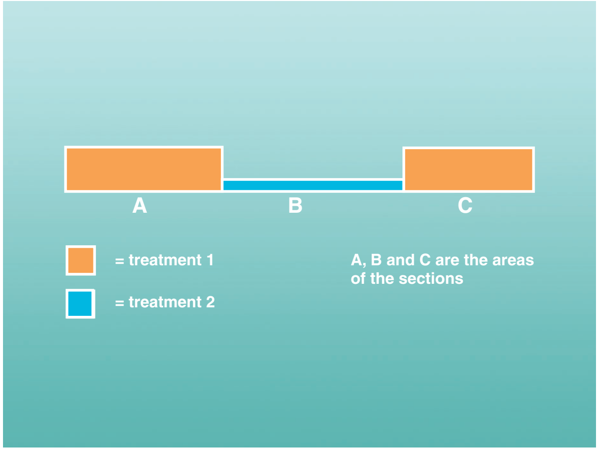

Figure 18: Should treatment 1 be continued through Section B?

Figure 19: Decision algorithm for combining treatment sections

Referring back to Figure 6, we have now completed *Treatment Selection*. The next topic is *Prioritisation* (Figure 20). Prioritisation is interesting because, as engineers, we invariably find that we want to fix everything and do a lot more work than we can afford to

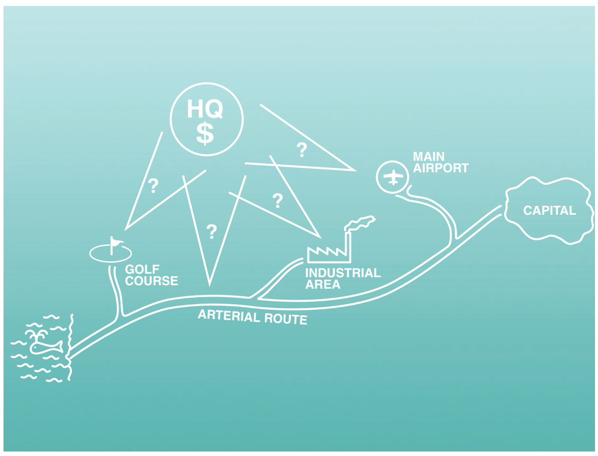

Figure 20: How do we decide where to spend our budget?

do. When I have worked overseas, it is my experience that nearly every time a system is run for the first time, it shows that something like 60-70% of the network needs some form of treatment. Now obviously all this cannot be done in the first year and therefore the work has to be prioritised. Prioritisation is a complex process; standards have to be set; representative conditions for the sections of road under examination need to be measured; a rolling programme and a budget have to be set up to achieve the standards, at network level, that have been set as the target to be achieved by a certain date. These are not trivial activities.

The first step is to set rational standards.

Figure 21: Set standards thatn can be achieved

Here we come to some very interesting work that both we at the University of Birmingham and our colleagues at TRL have been doing for many years, namely the development of economic models which allow us to do the tasks that I have discussed: working at network level, setting standards, and defining rolling programmes of work. TRL, in particular, is well known for its RTIM 2 model. The HDM III model is most closely associated with the World Bank and Bill Patterson. Much of the work was experimental, large studies being carried out in Kenya and the West Indies by TRL and by others in Brazil and in India.

After all this early work there was, for some years, very little ongoing development of the models. We began to think that another great leap forward was needed. This great leap forward proved to be HDM 4. Again both TRL and ourselves at Birmingham worked with many others around the world over the last ten years to develop HDM 4 to take economic modelling to a new plane, and to enable its use not only in developing countries but also in other countries such those in Eastern Europe. It is now being used in Poland for example.

HDM-4 (Figure 22) provides a standard model that people understand throughout the world. There are other models that do some of the things that HDM-4 does and, indeed, there are other models that do things that HDM-4 cannot do. Richard Abel of TRL, sitting in this audience, has been instrumental in developing some of these models for use in the UK. Other countries also have them, models such as DTIMS which is a perfectly adequate model and which uses a lot of the relationships out of HDM III.

Figure 22: The Highway Development and Management Model (HDM-4)

But HDM-4 is something we are very proud of at Birmingham and at TRL. I should also give huge credit to The Department for International Development for funding to allow this work to have been done; and, indeed, to continue it into the future so that we don't fall into the trap we fell into with HDM III where development ceased when the model was first launched.

Tools such as HDM-4 enable rational standards to be established. In simple terms the more that is spent on road maintenance, the better the condition of the roads. The vehicle operating costs, which, with reasonable traffic levels, actually swamp all other costs, will decrease as the roads get better. Therefore the total of road user costs and road maintenance costs (i.e. total transport costs) should display a minimum (Figure 23). Ideally this minimum is what we are trying to achieve.

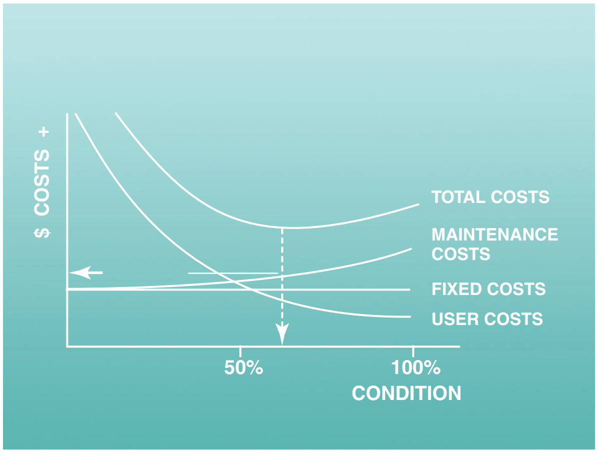

Figure 23: Relationship between total transport costs and road standards

However we want to maintain the roads with the minimum long run cost to the country and this desire points to the amount of money that should be spent year-on-year on the road network. So much for the principle. The question is, ‘Can it really be done like this?’ Happily the answer is *Yes* it can.

A specific example comes from Cyprus some years ago where we used HDM III to set the intervention levels in terms of roughness for the different classes of road. When we ran the system we showed that the higher the class of road, the lower the roughness levels ought to be (Figure 24). It would have been unfortunate if it had been the other way around! Lower roughness standards are required for the higher traffic levels on the dual carriageways than for the lower traffic levels on the minor roads in the outskirts of the country. These data were real and they went into a management system that I believe was in use in Cyprus until very recently; and therefore ran for something like 15-16 years.

Road Class	Roughness mm/km
Class A	1700
Class B	1800
Class E	3300
Class F	6000

Intervention Levels - Cyprus

Figure 24: Intervention road condition levels to trigger maintenance

Interestingly, the Cyprus work showed that it doesn’t really matter which specific maintenance strategies are adopted, within reason, as long as maintenance is planned and programmed with a suitable management process (Figure 25). For example it does not really matter if a thin overlay is applied every five years or a heavy structural overlay is applied every 14 years, the total costs and benefits are similar. This is a very useful result because it means that different mixes of treatments can be used throughout the network in order to keep as many people as happy as possible. This is a serious issue because everywhere there are political pressures!

Once the standards have been defined the next problem is determining the representative condition for a road. Many engineers see this in terms of road roughness but I do not like focussing on a single parameter. In some countries, for example, the focus is on structural integrity as measured by deflection, and whilst it is understandable why this happens, it should not really be done in this way. Instead, a number of parameters should be used to obtain an indication of the overall condition of the road. I would include both roughness and deflection, and also include rutting as well.

RESULTS:
Maintenance Alternatives for Class A Roads

	% of Total Costs calculated for routine maintenance
Routine maintenance only	100
Thin overlay at 5-year intervals with pothole patching	85.5
Regular overlay at 8-year intervals with pothole patching	84.7
Structures overlay at 14-year intervals with pothole patching	84.5

Figure 25: Relative costs of different maintenance strategies

But I would not include cracking because, although it is very important, it is actually very difficult to measure accurately. Eyes are hopeless for it. Machines are certainly coming that will be able to measure cracking objectively but they are not here yet. A recent review as part of a PhD thesis in Sweden concluded that nobody was really able to measure cracking very well yet—and that from a country where considerable expertise and money has been applied to this problem for a long time. This is rather depressing. The sooner we can solve it, the better.

Finally we have to develop a rolling programme and a budget to achieve the standards, typically over a ten year period. When running the models there are essentially two different ways of determining how to proceed—by considering individual roads or by considering the road network as a whole. The model can be run on every single subsection of road on every lane. Alternatively, road sections which are similar in terms of condition, traffic, structure and so on can be grouped together as shown in the matrix in Figure 26.

ROAD NETWORK MATRIX
Length of Roads (km)

Road Class	Contd.	Flexible Pavement Traffic High	Flexible Pavement Traffic Med.	Flexible Pavement Traffic Low	Gravel Pavement Traffic High	Gravel Pavement Traffic Med.	Gravel Pavement Traffic Low
Trunk	G	76	283	307	686	452	703
	F	485	762	561	855	904	1961
	P	911	420	321	1905	2432	4321
Feeder	G						
	F						
	P						
Urban	G						
	F						
	P						

Figure 26: Strategic level analysis

The standards can then be applied to the different boxes of the matrix rather than to every single road, thereby reducing the computational effort considerably. There is some debate about which method is best. Should we do the sums for every single road or should we do them for blocks of similar roads. Figure 26 shows the way that I, and I think all of my colleagues at Birmingham, would use. It is an interesting debate.

How should the priorities be set? This is actually very simple—it is essentially just a benefit-cost analysis (Figure 27).

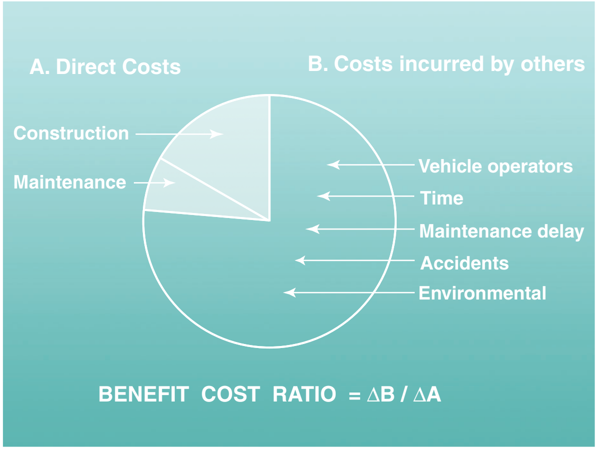

Figure 27: Benefits and costs

For each potential project we ask 'If a little money were to be spent on maintenance then how much vehicle operating costs would it save?' If the benefit-cost ratio is well above unity then we should be content (Figure 28).

Any increase in Direct Cost, ΔA
should be offset in reduction of User Costs ΔB

i.e. Benefit - Cost Ratio = $\frac{\Delta B}{\Delta A} \nless 1$

Figure 28: Benefit/cost ratio

The projects with the highest ratio are thus the ones which should be done first (Figure 29). Hence we should spend down through the priority values until we run out of cash. This is a very simple activity, although it can be dressed up in elaborate ways.

Returning again to Figure 6, we now come to the audit phase. In New Zealand, *Transit* use DTIMS as their economic model. They have a system that works very well. They have to make it work well because they have only got 4 million people and have to maintain a very long road network—it is a long thin country. At the end of the year it is said that the only thing that can be guaranteed is that the answers emerging will be wrong. The results are then audited to find out why they are wrong and this improves the relationships here and there, so that every successive year the results are less wrong than they were. This is what we should all be doing. Sometimes we forget. We produce the works list for next year and conclude that the problem is sorted out and that we have finished! But in truth the next task should be to see what went wrong last year, and improve on it. We must go on improving the relationships: this is very, very important.

PRIORITY

GIVEN BY

NPV

(TOTAL TRANSPORT COST SAVINGS OVER DO NOTHING CASE)

Divided by

REMEDIAL WORKS COSTS

Figure 29: Economic indicators to set priorities

Thus with good data, a knowledge base, and a systematic process we can solve our problem. That concludes the principles.

I would now like to look at some working systems. The first is a system that we put together under the *EPSRC LINK* scheme. We produced a working process based on the principles that I have discussed. The work-flow through this system is shown in Figure 30. There are four main parts; Figure 31; the first is setting the standards which is at the bottom left of Figure 30; the second is collecting data; the third is in determining the optimum long-term rolling programme for the network as a whole (LTRP) to comply with the needs of the road authority (i.e. the agreed standard). Finally the fourth part is to devise a sensible year-one works programme which complies with the overall long-term rolling programme.

Up to now I have said that the standards are set using an economic process. That clearly cannot be entirely true. In reality we have to comply with legislation and there are contract performances that have to be met regardless of the economic results. There are also socio-political pressures to cope with. This leads us

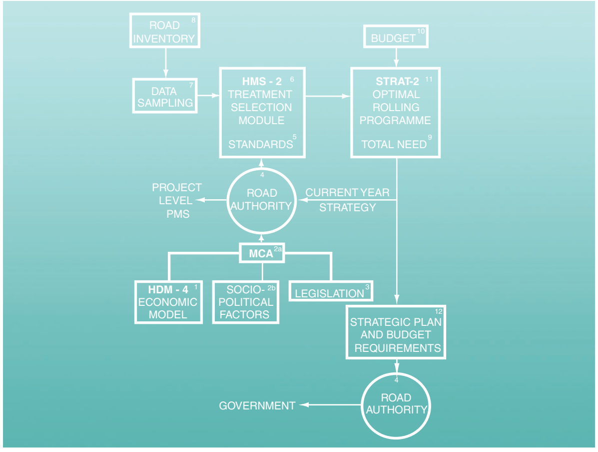

Figure 30: The strategic planning model (SPM) flow chart

Figure 31: Uses of the strategic planning model

to the current belief that we should be working through a multiple criteria analysis process where the economic standards are only a part. This is a great improvement because it will take us to the next level of how we should be setting standards.

The next part is collecting data. Figure 30 refers to 'data sampling' but I am not happy with sampling for reasons that I have already explained. The point is that we must get sufficient good data from the roads themselves.

Then we set our long-term rolling programme of works, in this case using HDM-4.

W S Atkins are using this system in some of their 'super agencies' in this country and it is working very well. Figure 32 shows the results of a trial done by my colleague Dr Costello. He compared the priority list developed by his colleagues in the 'super agency' down in the south west of Enland with the priority list identified by the system. It can be seen that in essence all the priorities except one are the same. The one that is different is different simply because of socio-political considerations that caused the project to be transferred to a later date. That knowledge had not been incorporated in the system. But all the other priorities are the same as engineers working with economists would have made using a much more time-consuming process. This is evidence that systems of this sort are now getting to such a level of sophistication that they can rival expert panels of economists and engineers.

Scheme	Conventional Process Year (Priority)	HMS-2 Priority Parameter (Priority)	
Taunton Cross - Axminster	2000 (1)	5062	(2)
Winterbourne Abbas Village	2000 (2)	4599	(3)
Little Bredy Duals	2000 (3)	4540	(4)
Bridport Bypass	2001 (4)	7528	(1)
Winterbourne Abbas to Friary Press	2001 (5)	2475	(5)
Little Bredy Dual to Winterbourne Abbas	2001 (6)	1950	(6)
Chideock to Bridport	2002 (7)	1530	(7)
Morecombelake to Chideock	2003 (8)	1512	(8)
Charmouth to Morecombelake	2003 (9)	1052	(9)
Mount Plesant to Wilmington	2004 (10)	941	(10)

Figure 32: Comparison of prioritisation by knowledge based and traditional means

The system is also in use overseas. The generic ideas that I have been talking about earlier are therefore now coming together as real systems. They are modular—because I think that they will be using whatever components they like. It is the process of dealing with data in the way that we have discussed that is really at the heart of it. We are trying to find a logical process.

I am going to finish with what I regard as four interesting problems that still have to be solved (Figure 33):

- The first is how to categorise network condition. I do not think we are yet there and I do not know how to do this very well.
- Setting condition standards is also quite difficult. I believe we need to develop multiple criteria analysis much further along the lines that my colleague in W S Atkins has been working on recently.
- Improving the modelling process is important—that goes without saying—and auditing.
- We need to build capital valuation into the process because everything we have discussed to date has actually been about recurrent cost analysis: we put money in, we save costs later. A frequent problem in developing or sparsely populated countries is that insufficient benefit emerges from the cost-benefit analysis to show that we should upgrade a road from one year to the next. So year after year it doesn't get upgraded, until finally it has fallen to pieces and we then need a huge sum of money to rebuild it. We could get over this if we were all the while

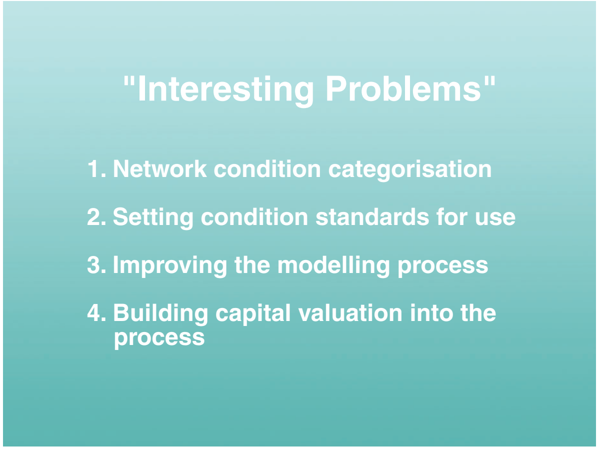

Figure 33: Interesting problems

building in capital valuation of that part of the asset into the recurrent cost process. It would be a very interesting thing to do. It is one of the reasons that I'm working in New Zealand at the present time with Transit. In fact it is a huge thing to solve.

DISCUSSION

Rod Kimber

Martin, thank you very much for an extremely interesting lecture about a complicated subject. You really made it very much clearer for us. You have provided a grand sweep—describing processes that have world wide implications and touch on the economies of both developed and developing countries.

Question

In your penultimate slide you put up four interesting problems. I'd like to add a fifth, which is the question of the availability of skilled resources and the quantity of those resources. This applies particularly to emerging nations and developing countries. Do your models take that into account?

Martin Snaith

That is a very interesting point. It is one of the things that drove us forward 25 years ago. We were working with the TRL in Kenya and we were terribly aware that there were so few good people around who could actually make decisions on the road. At the time we were measuring, deflection with a Benkelman beam, rutting, cracking and roughness. All these data were being collected on sheets of paper and stored all over the place and not really being analysed very well. Getting skilled people to make decisions from that was almost impossible. That is what drove me to developing my first database system on an old computer which was in the bottom of the Treasury building. We loaded all those data onto it and then either I, or the very recently late lamented Tom Jones, could start to make decisions. There were just two people available who could actually look at those data, handle them quickly and make sensible decisions about what should be done on the roads of Kenya; and also train other people to do the same thing. If you could take the brains of the few people around and build them into the system, you could, in fact, manage on a large network in an objective manner without having to have huge numbers of highly trained staff.

At Birmingham, for some 20-25 years now, we've been training MSc students who go on to take middle and high ranking positions in public works departments around the world. I think we've trained something like 500 engineers. The ones who have ended up in the roads branch are probably the only ones in the country who understand how to do it. It is difficult to get uniformity throughout the network. Your point is well taken.

Question

Data speak volumes, but have you ever tried to square the circle, particularly in emerging countries—following on from the previous question—and actually taking engineers, blindfolded and away from the data, to see what they would pick up as their high priorities? Then match the result to your knowledge model?

Martin Snaith

We have. That is actually a core part of our introduction and training processes and I again draw on the work we have done with TRL. The very first management system we put in was in Thailand many years ago, and it was only taken out of commission about two years ago. When we had got it up and running, Dick Robinson assembled a whole crew of people out on the roads saying ' Here are the data; here is what the system says; now what do you think should be done?' Sometimes they would agree with the system, sometimes the solutions would be different.

One story, from the Thai project, illustrates this. The question was, 'How do you tell the difference between a very fatty but stable asphalt road surfacing and a 'squishy' material where there has been a lot of bleeding and from which bitumen has been lost from deep down in the pavement, resulting in an inherently unstable mixture?' After much discussion we decided that the way to do it was to take a five Baht coin, drop it on the ground, tread on it for ten seconds, and then lift it up. If there was an indentation left behind, the problem was bleeding. If not, it was a rich mix that was stable. We wrote this into the manual but somebody said 'You can't write that'! We asked why not and they explained that it would mean treading on the King! So we to change the manual.

Question

One of the more difficult things is prioritisation, which you talked about and said was easy. The benefits of doing a job this year rather than next, I suppose, will not change very much unless there is development going on which would cause the traffic volumes to change. But there will be extra costs of not doing the job because next year's costs will be greater. Do the models cope with that? Or is that your fourth point put in a different way?

Martin Snaith

When we are modelling things at the network level, we use something like HDM-4. This will look at the overall state of the road which is, of course, thousands of little sections of road all of which are behaving differently. What we are trying to do is to identify the sections that just about arrive at the terminal condition as far as the performance criteria are concerned. To miss any would cost us much more to repair them in the future. The optimisation process in the model will cope with that. What it does not cope with are sections of road that have completely failed. The optimisation process could not cope with that because we should then be dealing with what some of our colleagues call 'worst first'. For 'worse first' the economic argument falls because, while you are fixing these, another section is failing, and then another and another, and it will, in turn, cost more to fix these. So they have to be treated [superficially/ specifically….] for the time being to make sure that they don't keep failing. If there is a backlog of sections of road that failed some time ago, one does not want to make that worse by not keeping the periodic maintenance going, properly optimised.

Supplementary question

Are local authorities tending to do what they should be doing?

Martin Snaith

I cannot answer this because I do not work with local authorities. The only quasi local authority I work with is the Northern Irish Road Service and certainly in that case we do not fall into that trap.

Question

My question is about the slide in setting standards. The Highways Agency went through a national audit last year and one of the questions they asked us was 'had the Highways Agency consulted their users as to the standards they wanted the network to be maintained to?'. The answer was: *not really*. There are mountains of paper which set standards but none of those have truly been produced from consulting road users—they were all based on engineering. So this year, 2004, focus groups and road users will be consulted concerning the standards that they would consider acceptable to try to tease out these issues. Some of these could be incredibly difficult to address, such as the willingness to pay for standards and the trade off against investments across other Government expenditure. Have you views in that area or on the basis of experience elsewhere in the World?

Martin Snaith

Yes, that's the point of the multiple criteria analysis process—to try to get the different stakeholders to contribute to the process, at the same time educating them so that they understand that if the standards go up they are going to have to pay more. My colleagues in the Swedish National Road Administration would suggest that they have managed to get sensible standards applied in the local areas by involving the local authorities much more than before. At first, when they started to do this, the local authorities said that, for example, 'for gravel roads, levels of grading should be much higher and there should be much lower levels of roughness'. The only way to concentrate their minds was to say that central government would give a base amount of money to keep the roads at what they thought were the right standard and if the local authority wanted better standards they will have to fund it themselves. That concentrated the minds of the local communes much more because suddenly they realised that there was a price to pay. I think we should be going down this route. We should be using sophisticated techniques to make sure that we get the right weightings for the different things. Jose Ortiz Garcia has written a paper on the subject.

José Ortiz-Garcia

Yes one has to involve all of the stakeholders in order to get a set of condition standards that satisfy the objectives of all the stakeholders; the public, government and politicians. And to do that one has to go through focus groups. We have the academic framework, but it has not yet been put into practice.

Comment

On users preferences, Martin mentioned earlier that he'd examined an interesting and relevant doctoral dissertation, and so did I recently. This was concerned with an attempt to illicit preferences for attributes of road quality. It certainly leads me to endorse the comments from José Ortiz-Garcia. In principle I think that this type of work is possible and, indeed, I think it has relevance beyond simply refining the standards. In the context of our current position with infrastructure it is also clearly highly relevant to the role of standards when an increasing proportion of infrastructure will be provided commercially. The issue of willingness to pay for superior quality is already being played out very dramatically in respect of travel times by private sector infrastructure providers and one can see every likelihood of that quality angle being played with respect to the dimensions that Martin was explaining earlier in his presentation. I think it is potentially extremely important not only for existing infrastructure but for the 'shape' of the infrastructure we shall see in the future.

Martin Snaith

I very much agree with that.

Rod Kimber

Thank you Martin. On that interesting note I think we have to draw to a close. There is a lot more that could be said but we have arrived at our target time. Thank you Martin for a very stimulating and interesting lecture on a complicated subject. It bears strongly on the economics of national policies, and you have drawn it all together in a very coherent way.