Element 2 Bid – Hertfordshire

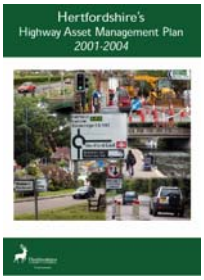
Use of Carriageway Deterioration Modelling in Hertfordshire's Asset Management

1. Background

Hertfordshire's transport infrastructure is by far the most valuable asset for which the county council is responsible. When valued on an asset management-based renewals approach, the network has a gross value of £4 billion and depreciates at around £30m per annum. It is also the 'universal service' on which all others ultimately depend and, as such, the provision of a network that is safe, serviceable and available to all users is vital to the county. However, it goes without saying that the service must also be provided in the most cost-effective manner to ensure value for money.

Hertfordshire's initial move to asset management in the highway field sprang from a Best Value review of the service carried out in 1999. The review concluded that the public wanted an improved service but did not want to pay more for it. This drove HCC to seek ways of delivering a step-change in the service and led to the adoption of the asset management approach, which emphasises the use of data to drive informed, long-term planning and decision making in order to make the best use of the available resources.

Looking at service examples from around the world, it became apparent that Australia and New Zealand, in particular, had much to offer as well-advanced practitioners of highway asset management. The New Zealand-based company Opus, a private-sector consultancy that had developed from the government roads agency, seemed to have a great deal of knowledge and experience to offer Hertfordshire and HCC arranged for some key Opus staff to be seconded to HCC on a long term arrangement to offer help and advice and to build internal capability in the field.



The first major fruit of this collaboration, Hertfordshire's Highway Asset Management Plan, was duly published in 2002 and generated a great deal of interest in the industry as the first plan of its kind in the country.

National guidance in the form of the CSS Framework for Highway Asset Management (to which HCC contributed significantly) followed in 2004.

Besides offering general help and support on asset management, Opus were able to offer HCC a number of specific asset management tools, perhaps the most significant of which was deterioration modelling for carriageways. The carriageways contribute around 80% of the gross replacement cost of the highway asset, making them by far the single most significant asset group. It also means that they offer the single biggest opportunity for improvements and efficiencies and makes them the logical place to start.

The CSS framework offers the following definition:
"Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers."

This highlights three key strands of asset management:

- Ensuring optimal use of resources
- Taking a long-term, lifecycle approach
- Focusing on current and future customer needs

Carriageway deterioration modelling offered the opportunity to address all three of these points through a single, coherent approach and was therefore one of the first asset management tools that HCC decided to implement.

2. Strategic Aims

Although time has moved on and the original HAMP has now been replaced by our Transport Asset Management Plan, the original fundamental objective of improving value for money remains the same – whether that means delivering more service for the same money or the same service for less money.

The introduction to HCC's TAMP states:

The role of the TAMP is to link our strategic objectives to the operational policies and procedures. It does this by ensuring that, when we create or review policies, procedures, programmes or practices, we do so in an objective, informed way with our strategic drivers firmly in mind.

These strategic drivers start with the Sustainable Community Strategy, feeding through to the Corporate Plan and Local Transport Plan. Further targets may be set in the Local Area Agreement with overall performance judged as part of the Comprehensive Area Assessment. The TAMP aims to ensure that these strategic goals are reflected in our operational plans and, ultimately, the work we do on the network and therefore aims to be a flexible framework capable of adapting to changing circumstances while still keeping us focused on key strategic goals.

The importance of the transport asset is well reflected in a number of the strategic documents mentioned above. As is to be expected, HCC's LTP includes specific targets for the condition of the asset as well as numerous other transport objectives. Additionally Hertfordshire's corporate plan sets out seven key Challenges that HCC sees as being top priorities locally, many of which are closely linked to the various transport assets. In addition to more wide ranging objectives related to safety and use of resources, two of these seven Challenges are specifically transport related: "*Tackling the causes and impact of congestion"* and *"Dealing with worn out roads and pavements"*.

Whilst deterioration modelling is a key element of our strategy for "Dealing with worn out roads", it is a long-term process requiring time and investment in order to achieve the desired results. It is therefore important to emphasise that

Challenge 5: Dealing with worn out roads and pavements

What it means

• Halting the deterioration of key parts of the road and pavement network through a combination of investment and targeting of resources

What success will be like

Better condition roads and pavements.
Public confidence in properly maintained roads and pavements and a five-year investment plan agreed by Government.

Key actions

• Additional £10million invested in enhanced maintenance strategy, plus rest of the budget utilised to maximum effect

• Developing the Transport Asset Management Plan to co-ordinate and integrate all activity on the road and pavement network, including maintenance works

• Targeting baseline and enhanced maintenance funding to achieve maximum benefit in terms of performance indicators and asset value

• Establishing performance indicators, in negotiation with the government, to better monitor in the long term the condition of the highway asset

• Raising awareness of and publicise information about our work on the network

Extract from "An Even Better Place to Live and Work", HCC Corporate Plan 2006-2009.

there is buy-in to the asset management approach at the highest level and that this is reflected in corporate strategies and priorities, as the extract from the Corporate Plan demonstrates.

The Corporate Plan also identifies the need for additional funding and the intention to find it, where possible, at least over the 3 year life of the Plan. The first two years of this additional funding have already been successfully delivered and the third year is currently under way.

The following carriageway strategy was endorsed by Members in 2006 to underpin the additional investment; some terminology has now changed but the intent remains the same:

Carriageway Strategy:

Using a combination of the deterioration model (which uses an internationally recognised computer model to help predict road deterioration and, consequently, pick the optimum time to intervene) and local knowledge and engineering judgement, a programme would be prepared using the following basic principles:

- ***A Roads***

  With a few exceptions, the A road network is now in a good condition, following a sustained programme of planned investment over the last five years. This is reflected in the current BVPI condition score. It is proposed to maintain the A road programme at its current level, whether or not additional roads investment is made available, in order to maintain and protect the investment in Hertfordshire's main arteries.

  In other words, it is suggested that any additional investment Members choose to make available would be targeted at the local roads and footways.

- ***Local Roads (B, C and unclassified roads)***

  The local roads are generally in a poorer condition than the A roads, as demonstrated by the level of reported faults and the scores for BV97a (B&C roads) and BV97b (unclassified roads).

  Under the enhanced funding scenario, it would be possible to strike a balance between tackling the backlog of repairs to the worst roads while using less costly preventative treatments on other sections of the network to prevent them deteriorating to the point where they need expensive repairs in the future.

  This would give an immediate positive impact on the condition of the road network and also given longer term benefits, beyond the suggested period of enhanced spend.

3. Carriageway Deterioration Modelling

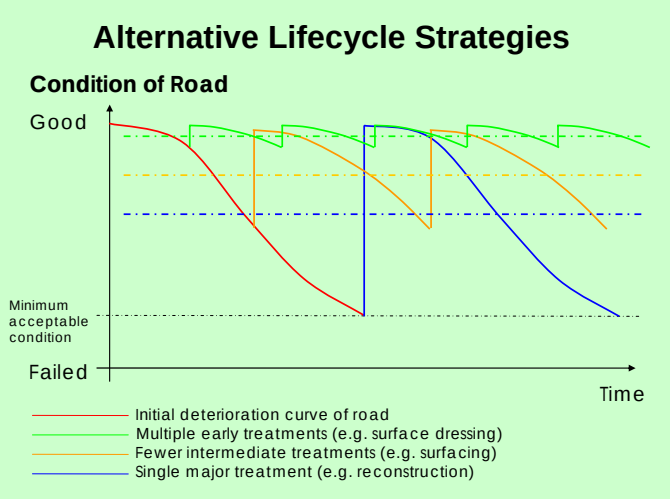
3.1 Tactical and Operational Objectives

If HCC's strategic objectives can be summed up as 'improving the roads and making best use of the money' how does this translate at a more practical level and what do we need from deterioration modelling to help deliver these objectives?

At a tactical level, we want to be able to identify the overall current and future need in the network and to be able to predict either the level of service a defined budget will give us or the budget required to deliver a defined level of service. This is crucial as it enables Members to take informed choices about the level of investment they wish to make in the asset, now and in the future. It also helps to manage expectations by allowing the setting of realistic and measurable targets.

Operationally we want to identify the most appropriate treatment for each road section. We also want a programme that meets strategic objectives (in this case delivering the best condition for the available money) and also allows us to plan ahead and coordinate with other works to reduce disruption and benefit from any potential synergies.

3.2 The Challenge



We know that it is frequently both cheaper and more effective to maintain a road before it falls into poor condition than it is to repair it afterwards. Maintenance treatments are often cheaper and less intrusive than repairs and consequently have less of an impact on the environment (less new aggregate to quarry and less waste to process) as well as generally being quicker and therefore less disruptive to road users. In addition a well maintained road reduces reactive costs such as pothole repairs and, perhaps most importantly, offers a better level of service to the public. While they are not a universal panacea – not all problems can be solved with a cheap preventative treatment – road deterioration can often be significantly delayed with an appropriated 'stitch in time' treatment meaning that these kinds of preventative maintenance treatments should form the core of the lifecycle plan for the asset. The important (and difficult) thing is to identify and act on those opportunities at the appropriate moment. All too often we are able to look at a road full of potholes and think 'if only we had done something a few years ago….' However, by the time these problems manifest, the optimum moment for a preventative treatment has usually passed and the road has generally reached the point where a more costly repair is the only option.

We have a great range of condition data derived from sources including CVI, SCANNER, SCRIM, safety inspections and public reports. Picking the worst roads is easy, our condition data makes that fairly straightforward. Using all this data effectively is more of a challenge. To get best value we want to identify 'stitch in time' not 'worst first' solutions and we want to pick them in good time to allow them to be planned and coordinated and still delivered at the optimum time. Since our resources are limited we also want to evaluate which of the many potentially beneficial projects will give us the best overall value in the long term so that the schemes we do undertake give us the maximum positive impact on the long term condition of the network. Using deterioration modelling gives us a range of outputs that helps us do all of this.

3.3 Deterioration Modelling Overview

Deterioration modelling (DM) is about predicting future asset performance over time. For Hertfordshire the Model assesses outcomes 15 years into the future and reports them for 10 years. DM also identifies the most appropriate time to intervene with a maintenance treatment, within the constraints that we give to the system. Optimisation is then used to find the most appropriate type of treatment and timing from those available. Treatments are not triggered at a defined point; instead they are allowed to occur within a suitable range. This means that we get the most appropriate treatment at the best time and, because we rerun the Model annually, timings and treatments are reassessed each year and can be revised in response to changing conditions. The Model then selects the best strategy, or combination of treatments, that maximise the network condition for the available funding across the entire analysis timeframe.

In effect the Model generates a mini lifecycle plan for each road section, selecting treatments to suit its needs. Then it rolls this up to a network-wide programme by selecting those treatments that offer the best value if we cannot afford to do everything.

Deterioration Modelling – Why do it?

- ***Plan programmes***
  – Not just next year but 5 or 10 years ahead
- ***Predict future trends in condition***
  – What happens if we spend more or less?
- ***Analyse and present options***
  – Give real choices to decision makers
- ***Optimise the programme***
  – Deliver the best value for money

The goal of DM is to generate many probable strategies and then use optimisation to select the appropriate timing, taking into account budgetary constraints. Consequently the resulting programmes can be said to be truly optimised, not just prioritised – the end result is the optimal long-term *outcome* for the network and its users. It should be stressed that the Model does not *just* select preventative treatments; it has at its disposal a full range of options from surface dressing through to reconstruction and will select the one that gives the greatest benefits. However, it is better able to predict and select preventative treatments than conventional methods that rely solely on *current* condition in decision making.

3.4 The Model

The Model is necessarily computer-based, since analysing and appraising all the options for around 18,000 different road sections manually would be an impossible task. The software used is a package called dTIMS CT although this is just a database capable of holding and manipulating the data required. The Model itself is a series of user-defined mathematical relationships describing how various measures change with time. The form and reliability of the Model depends upon the data available and our degree of understanding of how an asset actually performs and the impacts traffic and maintenance have on it.

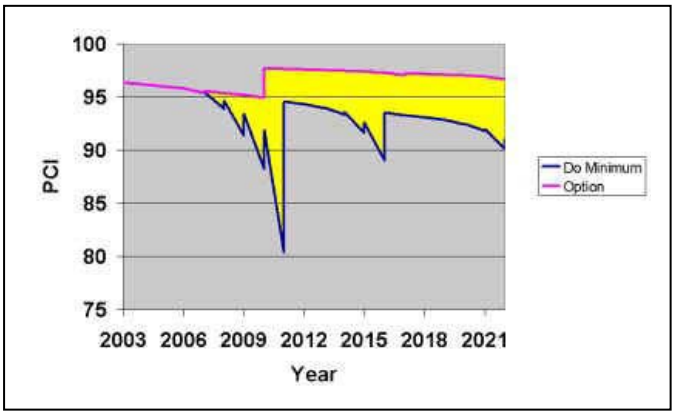
The Hertfordshire Model generally aligns to the PIARC-HDM (Highway Development and Management) system of models. HDM has two components: software and documentation. HCC and Opus have chosen to use dTIMS CT instead of the HDM software, as the open nature of dTIMS allows us to customise the analysis variables (see below) to suit the individual needs and peculiarities of our network. However we have chosen to implement the core of the HDM models, which are well documented and internationally recognised.

It is beyond the scope of a document such as this to look at the internal details of the Model however, in essence the Model takes a range of data, discussed below, and aims to predict the future condition of each road, based on the defined relationships referred to above. Once the likely future performance of the asset has been determined, a variety of options to maintain and improve that condition are modelled and compared to produce an optimum solution. These can then be rolled up to network-level solutions by selecting the most efficient individual solutions up to a budget limit, from which works programmes and network-level condition predictions can be derived for a range of budget scenarios.

Hertfordshire relies on Opus expertise to write and modify the expressions within the Model and to run the Model itself since the cost of purchasing the software and training people to use it effectively would not be justified. However, we bring the expert modeller over from New Zealand for a month each year to work alongside Hertfordshire staff who provide the key information around expected life, suitability of treatments, costs and so on as well as gathering and providing the necessary inventory and condition information on which the analysis is based. Thus the outputs are very much the result of a partnership between specialist expertise on one hand and practical knowledge of Hertfordshire's network on the other - both elements are essential.

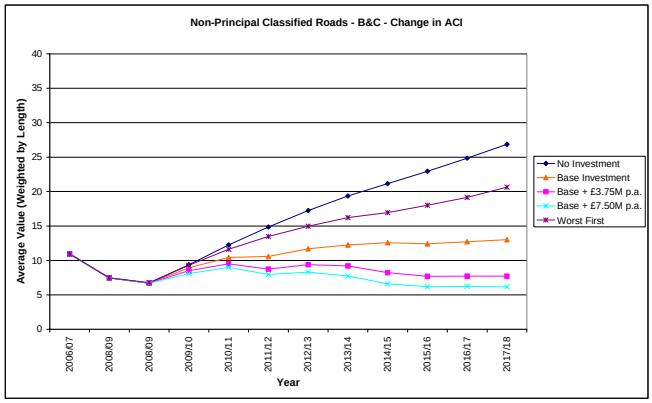
Once we have some initial outputs to consider, the modeller and HCC staff field test them by looking at a sample of sites to ensure that what we see on the ground accords to the data going in and that the Model is generating reasonable and plausible outcomes.

3.5 Analysis and Optimisation

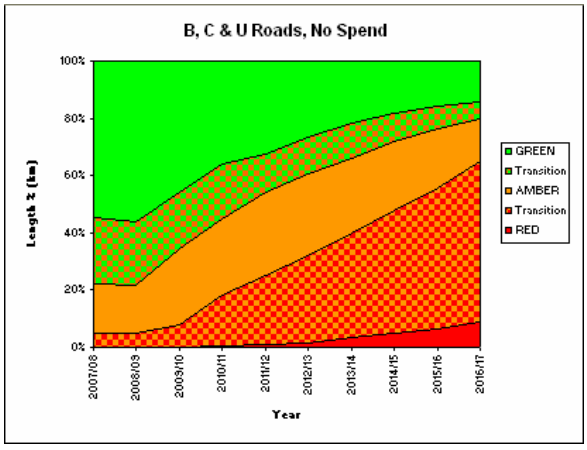


Analysis Variables define what it is we are trying to forecast from year to year or treatment to treatment. An Analysis Set pulls together many of the building blocks of the analysis, including which Analysis Variables to include, which treatments to include and in what order. This allows us to build in different rules for different classes of road (for instance) so that the Model cannot suggest inappropriate treatments.

Optimisation is the process used to select maintenance strategies that maximise the HCC Average Condition Indicator – our overall measure of network condition. We want the best possible Indicator for a given investment level, whilst minimising life cycle costs. The Model will evaluate a number of different scenarios and then compare their costs and benefits to determine the most efficient and beneficial scenario for each road. In the graph above, the Model is comparing a 'Do Minimum' scenario (the blue line) with an alternative 'Option' (the pink line). The relative costs of the two choices can be evaluated from HCC's cost sets for works and the likely cost of reactive works (such as filling potholes if we 'do minimum') can be derived from our records on our reactive 'Cat 1' service, linked to the projected condition. The 'benefit' of the option under consideration is effectively the yellow area between the two lines on the graph. The Model will consider a number of such options before selecting the best for each road; of course, in some cases, 'Do Minimum' will prove to be the most effective option, at least for now.



Many differing overall budget scenarios can be established and tested to determine the most appropriate scenario for the network. As the Model gives a prediction of future condition based on the budget scenario and the suggested treatments, it is possible to project future network condition indicators based on the different scenarios. The graph to the right shows a range of such scenarios tested for the B&C road network. This kind of analysis allows Members a clear view of the options available, and the consequences of those options, allowing for robust and informed decision making. We can also do a more detailed analysis of individual budget scenarios. The graph to the left shows the relative proportions of the network that are projected to fall into difference condition bands under a given scenario (in this case a 'bare minimum' scenario with no planned works). The condition bands are shown in a Red/Amber/Green format so that they are easily understood. As might be expected in this type of scenario, the network is likely to deteriorate significantly.



3.6 Data Requirements

The DM is a data driven process. While this makes it robust and objective, it also makes it a long-term process and means that the up-front costs can be significant; gathering good data is not cheap but the quality of the end product is highly dependant on the quality of the data used. Data used includes:

- An inventory of assets to obtain quantities
- Unit rates for replacement/rehabilitation
- Traffic (AADT), Percentage HGVs and Loading Per HGV
- Some measure of pavement stiffness (structural number)
- Pavement type, age and depth
- Surfacing type and age
- Some measure of condition preferably in terms of cracking, rutting and roughness.

The modelling is repeated on an annual cycle. Therefore, to demonstrate progress and make reliable forecasts about network need, it is essential the inventory and condition data represents the true state of the network and is updated when maintenance and capital works occur. To ensure up-to-date condition data for the Model, Hertfordshire has been collecting condition data on its entire carriageway network each year since 2001; a considerably more rigorous regime than required for BVPI purposes but one which now gives us a good depth of historic data from which to draw trends.

This detailed analysis also gives the opportunity to understand and challenge our data and to drive continuous improvement. While the change to SCANNER on classified roads has given the data more repeatability and reliability, there are a number of issues with a machine-based survey that a human operator would not produce; for instance anti-skid surfacing can show up on the 3m Longitudinal Variance and thus suggest surface deterioration where none, in fact, exists. This work tends to suggest areas in which we could refine and improve the Model or the data on which it is based for future years. In the early years of the Model, we identified that the data on the construction of the network was, in most cases, poor or non-existent. While this is hardy atypical for UK local authorities, the Model needs some guidance on the construction and stiffness of the road it is analysing in order to make a reasonable judgement about its performance. To remedy this situation, we undertook a ground radar survey on the whole network to establish, at 20m intervals, the thickness of the bound and unbound layers of the road. With a more limited series of Falling Weight Deflectometer tests and core samples to calibrate this work, we have gathered the data the Model needs.

While we have successfully addressed a number of data issues in the past, there are always more ways to improve and refine the quality of the data we can put in to the Model and, thereby, the results we will get out. At the moment we are focusing on methods to improve the quality of the traffic data we have on lower categories of road. Since a network wide survey would be prohibitively expensive, we a re examining sampling techniques, land use mapping and available traffic models to improve the approximation of traffic loads on our local roads.

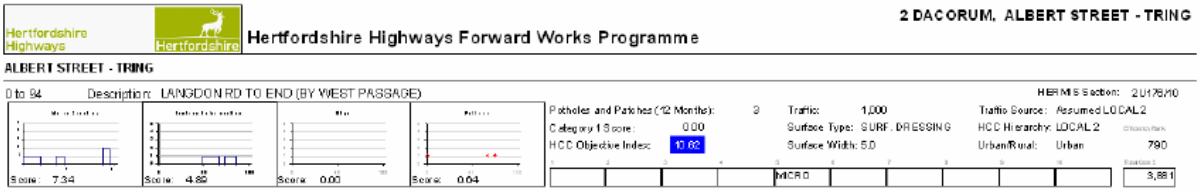
3.7 Key Outputs

In summary, the Model gives us a number of highly useful outputs, most of which have already been discussed in detail.

- Optimised Programme – to deliver best value for money by ensuring that the work we do has the maximum beneficial impact on the network.
- Forward Works Programme – to allow coordination with other works.
- Condition Projections – to inform strategic decision making. These can be related to both the nationally-recognised BVPIs and to HCC's own Average Condition Indicator, which is

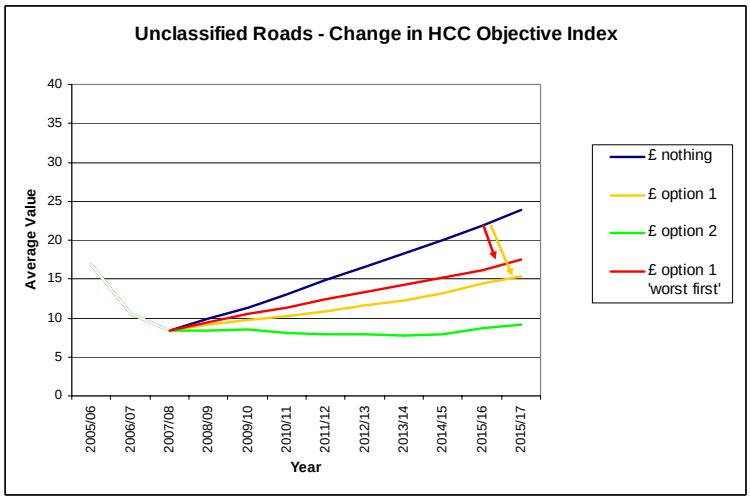
a better reflection of the whole network and is sensitive to the benefits of 'stitch in time' works in a way that BVPIs are not.

- Outline Treatments – act as a starting point for our engineers to develop the details of the schemes, supported by field sheets like those below which help them refer to the data the Model has used while in the field.



4. Value for Money

The deterioration modelling is not cheap. The direct costs in terms of the modeller's time and our own staff time are around £56,000 p.a. Where possible we make use of data we have or need to collect anyway but in other cases we have collected data more frequently than required (like CVIs on unclassified roads) or specifically for the modelling (like the ground radar surveys). In the first few years we were spending around £100,000 p.a. collecting additional data over and above our normal needs although this has now reduced to around £45,000 p.a.



On the other hand, the benefits gained from the modelling are substantial. Aside from the fact that our analyses allow for better condition forecasting and strategic decision making, the fact that we can optimise the programme to make best use of available funds offers direct benefits.

Using the Model and the same costs and predictions of underlying deterioration, we have rerun the Model with a 'worst-first' scenario, selecting sites not on the basis of their overall benefit but simply on the basis of which road is in worst condition. The graph above sets out the predicted results of the different scenarios. The blue line shows what happens to the network if we do no major works (a high score being a worse condition) and the green line indicates a more costly steady-state scenario. Both the red and yellow lines represent the same budget *amount* however the yellow line shows what that budget gets us if optimised whereas the red line shows the results if the worst-first path is followed. While both scenarios lead to deterioration, the optimised scenario shows the roads deteriorating slower – they stay in better condition longer for the same money. Using the 'do nothing' scenario as a baseline the optimised yellow scenario buys us about 30% more benefit than the worst-first red line for the same money. The relative benefits are represented by the coloured arrows.

We routinely model £10m-£12m worth of works on the carriageway network each year and it has been substantially more than that over the last few years with the additional investment HCC Members have made. Even on the basic budget however, that equates to gaining additional long-term value of around £3m for an annual outlay of around £100,000 - excellent value even before the intangible benefits of better analysis are considered.

The CIPFA report "Transport Infrastructure Assets: Review of Accounting, Management and Finance Mechanisms" undertaken for DfT and HM Treasury and published earlier this year recognised our pioneering work in asset mangement and, specifically, the benefits we gained from deteriortion modelling as examples of good practice in the field.

5. Handling of Change

The move to an asset management approach has not been without difficulties; gaining buy-in from Members, staff and the public to a strategy that apparently ignores some bad roads while treating good ones is not straightforward and is a process that is still ongoing. As such, the deterioration modelling is sometimes mistrusted by those who do not fully understand the reasoning behind it or who disagree with some of its suggestions.

From the start, however, Hertfordshire has endeavoured to engage key stakeholders in the asset management process. As part of the review of TAMPs undertaken for DfT by Atkins, Stuart Pile, our executive Member for Highways, Transport and Rural Affairs, was interviewed by Mike Bordiss, a consultant on the project with local government experience at a senior level. Part of the outcome of that interview is included in the extract below and it demonstrates that there is understanding and buy-in to asset management in general and modelling in particular at the highest level within Hertfordshire.

Extract from 'Review of Transport Asset Management Plans' by Atkins for the Department for Transport, January 2008, Section 5: Embedment of TAMPs; 5.4 Hertfordshire CC (part)

Ability to present a confident and robust case allowed the Cabinet Member to argue for and achieve an additional £10m pa for secondary roads. This is now holding condition and having a visible effect, especially on estate and rural roads. The Council accepts that asset management may not improve road condition BVPIs in the short term but takes a corporate risk based approach to maintaining its 'excellent' CPA. Political requests for maintenance work are declined and this has led to increasing respect for the programme.

Significant Learning Points

Development of an asset management culture and of a respected predictive model requires involvement of Members and staff over a considerable period.

The asset management plan is important for making and supporting resource decisions, but it is the output in terms of asset management programmes and confidence in the programmes which are valued.

However, while buy-in at the highest level is key, we continue to work to improve understanding at all levels. With new Members expected after next year's county council elections, we will be running a series of workshops to introduce them to the County Council's various services and asset management will feature prominently. There are also some internal changes happening within the client team in Herts Highways. One significant change is to bring the responsibility for developing the strategies and delivering the resultant programmes into the same team, where previously the delivery of schemes had been managed on a locality basis. This helps to ensure that the scheme objectives and strategy are clear to those delivering the works. These changes also present further opportunities to promote the TAMP and the philosophy behind it.

Hertfordshire is also regularly involved in conferences and working groups promoting the benefits of asset management and the deterioration modelling approach since the more widely these are understood and adopted, the easier it becomes to embed them.

6. Benefits Accrued from Deterioration Modelling

The key benefits have already been dealt with in detail as they occurred in the submission but, in summary, use of the Model gives us the following major benefits:

- Optimising the programme to deliver the best value for money: a little extra spent on modelling gives a significant improvement in performance.
- Plan programmes for years ahead to look for opportunities to link with other works: this helps us discharge our network management duty and coordinate with other interested parties such as utilities. It also delivers synergies with other HCC programmes such as improvement or safety schemes by combining works to reduce costs and disruption.
- Predict future trends in condition so that we can say what will happen if we spend more or less or what we need to deliver a particular level of service.
- Give real choices to decision makers allowing them to make informed, robust decisions in full knowledge of the options and consequences.

7. Ongoing Work and Future Projects to Sustain Benefits

The benefits of previous years' modelling and the resultant programmes of work will continue to accrue as roads which would otherwise have fallen into disrepair last longer. Hertfordshire continues to be committed to this approach and to ensure that it invests available money soundly to get the best long-term value. Recent additional funding from Members has allowed us to make significant inroads into the backlog of poor roads while still investing in suitable programmes of preventative maintenance.

Even, or perhaps especially, if this additional investment cannot be continued in the future, the fact is that we have the systems in place to target what we *do* have to where it will give the greatest benefits.

However, refining and improving the Model is an ongoing process and the Model is only as good as the available data. Thus we will continue to look for ways to improve the quality and scope of the data used in the modelling process. The steps we are taking to improve traffic flow and HGV data have already been mentioned and advances here will allow us to more easily identify those roads at risk from accelerated deterioration due to high traffic volumes and ensure that appropriate treatments are suggested for high-traffic roads.

Another area for potential improvement is the capture of condition data on unclassified roads. The use of SCANNER data on classified roads has led to a general improvement in the quality and repeatability of data on this part of the network. Since we no longer need to use CVI on the unclassified roads for BVPI purposes, we are now able to look at other techniques. The mini-SCANNER machine is one option although it is still unlikely to be suitable for all unclassified roads. An alternative possibility that we are currently exploring is a Canadian firm which has machine-based condition survey equipment mounted on a small motorbike. While this is unlikely to give the same range and quality of data as a full SCANNER survey, it could prove to be a significant improvement over CVI in terms of objectivity and repeatability and is something we are keen to see in action.

In conclusion, Hertfordshire welcomes this initiative to support and encourage asset management in the local authority transport sector. We would be happy to act as champions and to continue to contribute at regional and national level to developing and promoting asset management further and would welcome any additional resources available to help in this task.