PAVEMENT PERFORMANCE DATA ANALYSIS FORUM

Sponsored by the TRB Data Analysis Working Group
Hans J. Ertman Larsen, Chairman
A. Robert Raab, TRB Senior Program Officer

June 30, 2005
Trondheim, Norway

Morning Session

0900-0930am		Chairman's Welcome Staff Report
0930-1000am	1.	**Simulation of Damage Evolution in a Sprayed Sealed Road** Marco Costanzi and David Cebon Cambridge University Engineering Department, Cambridge, UK
1000-1015am		Presenters' Questions and General Discussion
1015-1030am		Morning Break
1030-1100am	2.	**COST Action 354 – Performance Indicators for Road Pavements** J. Litzka Technische Universität Wien, Vienna, Austria
1100-1115am		Presenter's Questions and General Discussion
1115-1145am	3.	**Road Condition Variables and Their Use in the Swedish Road Adminstration** Jaro Potucek Swedish National Road Administration, Borlänge, Sweden
1145-1200noon		Presenter's Questions and General Discussion
1200-0130pm		Mid-Day Break

Afternoon Session

0130-0200pm	4.	**Optimized National Road Maintenance Program Based On Database Queries** Andras Gulyas Technical and Information Services on National Roads, Budapest, Hungary
0200-0215pm		Presenter's Questions and General Discussion
0215-0245pm	5.	**French Road National Network Study Using Survival Models** Tristan Lorino Laboratoire Central des Ponts et Chaussées, Nantes-Bouguenais, France
0245-0300pm		Presenter's Questions and General Discussion
0300-0330pm	6.	**Interpretation of Rut Depths for the Norwegian Road Surface Profiler "ALFRED"** Einar Værnes SINTEF Technology and Society, Road and Railway Engineering, Trondheim, Norway
0330-0345pm		Presenter's Questions and General Discussion
0345-0400pm		Closing Remarks
0400pm		Close of Meeting

A NOTE ABOUT THE DAWG

The DAWG is an international forum for the discussion of methods of analysis of pavement performance data. Presentations at DAWG-sponsored forums address the technical interests of professionals engaged in highway research and engineering design, maintenance, and rehabilitation who are engaged in collecting, processing, and analyzing such data and developing insights into the behavior of pavements. Presentations offered by forum attendees (by prior arrangement) focus on work-in-progress concerning the development of techniques for extracting and analyzing data, and early results of recent applications of these techniques. Topics such as model building, sensitivity analysis, and development of transfer functions linking structural response to distress are especially popular and welcome.

A DAWG-sponsored forum has a minimum of formality to encourage open discussion among attendees and minimize the time between the presenters' preparation and dissemination of analytical results. The agenda is prepared in advance, based on responses to a call for abstracts. Abstracts are reviewed solely for conformity with DAWG guidelines, and as many as time permits are placed on the agenda. Presentations are not subjected to prior technical review. Copies of presentation materials are not distributed. Presentations are not published. Comments by forum attendees are not recorded.

DAWG-sponsored forums are held twice each year: immediately preceding the TRB Annual Meeting in Washington DC in January, and approximately at the midyear at another location. The midyear meeting is usually held in conjunction with a major highway pavement conference where it is expected that many attendees will also be interested in participating in a DAWG forum. If requested by the organizers, the DAWG will arrange and conduct a formal paper session conforming to all the policies and procedures of the conference.

As a TRB committee, the DAWG has appointed members who serve as a steering committee to guide the planning of future meetings. However, DAWG forums are open to everyone interested in the subjects to be discussed, and all attendees enjoy equal status. There is no registration requirement or fee required to attend meetings, but advance notice of the intent to attend a particular forum is recommended and appreciated.

Inquiries are welcome from those interested in adding their names to the DAWG's mailing list, and those wishing to submit abstracts of presentations for consideration for presentation at a particular forum. Inquiries and abstracts should be directed to Dr. A. Robert Raab, NA-443, Transportation Research Board,
500 Fifth Street NW, Washington, DC 20001, Telephone: 202-334-2569, Fax: 202-334-3471, E-mail: rraab@nas.edu .

TRB's DATA ANALYSIS WORKING GROUP ("the DAWG")
PRESENTATION ABSTRACT FORM

TITLE OF PRESENTATION:

ABSTRACT:

(Guidelines:

- *Any person who wishes to brief the DAWG on the status of his/her unfinished and unpublished work is invited to submit an abstract.*

- *Each abstract must contain a small set of questions on issues being considered by the submitter in the further development of his/her project.*

- *Each briefing will be followed by a period devoted to consideration of the presenter's questions and requests for advice.*

- *Briefings should focus on techniques for extracting, processing, and analyzing pavement performance data, as well as preliminary results of applications of these techniques.*

Note: Please delete the guidelines and use this space for your abstract.)

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1-

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3-

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

NAME:
MAILING ADDRESS:
TELEPHONE/FAX/E-mail:

Completed forms should be sent to:
A. Robert Raab, PhD, PE, FASCE
Senior Program Officer, TRB
E-mail: rraab@nas.edu

SIMULATION OF DAMAGE EVOLUTION IN A SPRAY SEALED ROAD

Marco Costanzi and David Cebon
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ABSTRACT:

Sprayed sealed construction is used in Australia, New Zealand and South Africa for roads with low traffic volumes. Surface deformation of spray seals is a strong function of load level and consequently they are sensitive to the dynamic tire forces imposed by heavy vehicle traffic.

In Australia, heavy vehicles with 'road-friendly' suspensions are allowed higher static axle loads than vehicles with conventional suspensions. To be considered road-friendly new heavy vehicles must pass a type approval test which measures their oscillation frequency and damping for a standard input. The current regulatory system does not have any requirement for suspensions to maintain their road-friendliness in service.

For air suspensions to pass the road-friendliness test, they must have fully functioning hydraulic shock absorbers. However these components wear with time and lose their effectiveness. This reduces the damping level of the suspensions and causes a substantial increase in the dynamic tire forces they generate during normal operation (for example, field tests on traffic using a UK highway showed that poorly damped air suspensions can generate significantly higher dynamic tyre forces than conventional steel leaf spring suspensions).

The motivation behind this study is to quantify the effects of inadequately damped air suspensions on the maintenance costs of spray-sealed roads in Australia. The approach is: (i) to develop a mathematical model of the interaction between a mixed fleet of heavy vehicles and the surface of a spray-sealed road; (ii) to validate the model using in-service performance data for representative roads; (iii) to use this model to predict long-term road maintenance intervention costs; (iv) to compare the predicted road maintenance costs for various vehicle fleet scenarios – varying proportions of conventional, road-friendly and poorly-damped air suspensions.

This presentation will focus on the model of vehicle-road interaction and its validation using in-service pavement performance data. Key features of the model include: (i) a simplified 'quarter car' model for vehicle dynamics, including detailed nonlinear suspension elements; (ii) careful accounting for the 'spatial repeatability' of tire forces generated by a fleet of vehicles and non-uniformities in the road construction; and (iii) use of accelerated pavement performance test data to model the evolution of the surface profile. The validation will use longitudinal surface profile, rut depth and deflection data for a spray-sealed Australian road, collected by the NSW Road Traffic Authority over a time span of three years (2001-2004); the same board supplied data about traffic level on the same road.

PRESENTERS' QUESTIONS: We would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

- The amount of data available for model validation purposes is limited to a three year span. Ideally the model should be validated using data from a much longer period – enabling significant distress to be observed. Do the attendees know of any other sources of long term performance data for spray sealed roads?

- The model of road degradation uses two important assumptions: (i) the distribution of the *strength* of the road (resistance to permanent deformation) is assumed to be related to the distribution of Benkelmann beam deflections (stiffness); (ii) the spatial distribution of strength is assumed to be uncorrelated with the surface profile. Are these assumptions reasonable? Is there data available that would confirm or improve upon them?

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COST 354 – PERFORMANCE INDICATORS FOR ROAD PAVEMENTS

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Abstract:

The specification of performance criteria from the perspective of road users and road operators is a key prerequisite for the efficient design, construction, maintenance and operation of road pavements. The extent to which goals are reached or performance criteria satisfied can be quantified by calculating special indicators or indexes characterising the road pavement, which in turn permits an assessment of the efficiency of certain approaches from both a commercial and a macro-economic standpoint.

For a Europe-wide harmonisation of standards to be met by road pavements it therefore appears useful and appropriate to specify pavement characteristics in terms of uniform "performance indicators". For this reason the COST-action 354 "Perfomance Indicators for Road Pavements" was initiated with the main objective to define uniform European performance indicators and indexes for road pavements taking the needs of road users and road operators into account.
In the context of the action single performance indicators as well as combined performance indicators should be defined for different road networks and pavement structures taking into consideration functional and structural demands of road pavements as well as demands from the environmental point of view.

At the moment 21 European countries are involved in this COST-action, which started on 17th March 2004 with the collection of existing information of performance indicators (type of indicator, field of application, assessment and classification, type and extend of collection, etc.) in the different countries. In the meantime these information were implemented in a special data base and prepared by working group 1 for the following up work of working group 2 (selection and assessment of single performance indicators), which started with its work in March 2005.
Since the kick-off-meeting 2 meetings of the management committee and in total 7 meetings of working groups 1 and 2 took place. For the next months also short term scientific missions are under preparation.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matter:

- (To be provided at the forum)

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

ROAD CONDITION VARIABLES AND THEIR USE IN THE SWEDISH ROAD ADMINISTRATION

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ABSTRACT:

In the Swedish Road Administration (SRA), the difference is made between so-called functional and technical condition. They are handled in different way. Functional condition covers condition variables primarily influencing the traffic. Technical condition covers condition variables primarily influencing the road network preservation (and the traffic in the long term only).

The condition variables are used to

- describe maintenance standard specifying trigger values for the variables
- assess backlog according to the maintenance standard
- assess condition-based road capital value.

Maintenance standard is defined by using trigger values for condition variables. The trigger values are selected with regards to road preservation for technical condition and with regards to road user effects for functional condition.

Compliance to maintenance standard is monitored using the term “backlog”. It is defined as cost of optimal road works to be performed on road components that have some condition variable value under trigger values of maintenance standard. Its value for paved roads is about 1400 million euro.

The backlog as defined above covers only road segments with insufficient condition in relation to the maintenance standard and alone is not a sufficient measure. There can also be a “hidden” backlog depending on unfavourable condition distribution of road segments with still sufficient condition values (many roads close to the trigger values but still on the right side). Road capital value is then considered to be a complement to the backlog in future.

Maintenance efficiency in the SRA is proposed to be assessed using formula:

Periodic Maintenance Efficiency = Condition Improvement / Road Works Costs

Road condition is so far expressed in terms of backlog regarding maintenance standard.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

- Is classification of condition variables and features described above common?

- Is the presented set of condition variables used for paved roads common?
- Are there organizations expressing maintenance standard in similar way?

- Are there any examples of the backlog composition for other road networks?
- What alternatives methods for assessment of road capital value are used?
- What alternatives methods for assessment of maintenance efficiency are used?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

OPTIMIZED NATIONAL ROAD MAINTENANCE PROGRAM BASED ON DATABASE QUERIES

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ABSTRACT:

A considerable maintenance backlog occurred on the Hungarian public road network recently. While the government has put emphasis on the development of the high-speed network, the problems of existing roads must not be forgotten. The Road Management and Co-ordination Directorate started to establish plan and resources for a National Road Maintenance Program in 2004.

Traditional PMS cannot be used at the very constrained resources that can be forecasted realistically. An optimal mix of desired maintenance activities has been planned therefore using database queries. The National Road Databank is suitable for such queries consisting of complex logical expressions including pavement condition, drainage condition and traffic volume variables. Different queries give different lengths of sub-networks or road sections as a result which also can be expressed as a proportion of the total road network. Based on the length of sub-networks and the required maintenance activities on those sub-networks, applying reliable unit costs the required amount of resources for program components can be calculated and optimized.

The optimal proportions have been determined by an expert committee using the trial and error method. The goal function was the minimum cost of all program components. Queries were varied to gradually increase or decrease the length of sub-networks for a certain program component to get closer to a presumable optimal solution. The main aspect was the proper proportion of the given maintenance activity on the appropriate sub-network length. An important factor was to reach equilibrium between main and secondary roads.

At this step the road sections themselves were not yet important. When the optimized proportions of different maintenance activities are ready, the sub-networks are sent to district road administration units in order to specify the road sections concerned taking into account local characteristics. The result of the above-described process will provide a National Road Maintenance Program in 2005, determining tasks and resources for the next 2 years and for longer terms.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

- Does anybody have experience with similar large-scale network maintenance optimization programs?
- Are there any procedure or method to solve optimization equations containing variables in logical expressions?

- Are there any possible heuristic solutions for similar complex query problems?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

FRENCH ROAD NATIONAL NETWORK STUDY USING SURVIVAL MODELS

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ABSTRACT:

The French pavement management system is based on the IQRN (*Image Qualité des Routes Nationales*) campaign, which consists in monitoring the entire national network every three years (in fact, one third every year). Data concerning both structural and surface characteristics are thus available since 1994 for the 30,000 km of national roads. Statistical analysis of the surface distresses have been conducted at the LCPC in order to determine parameters which are governing the deterioration process and to predict residual pavement lifetimes. Several models (linear or non-linear regression models, Markov chains models, survival models…) have been adapted to perform these statistical analysis of pavement data, and primarily cracking.

The primary goal of this study is to assess the role of endogenous (structural parameters) or exogenous (traffic, climatic conditions) covariates into the cracking process, including the use of a statistical methodology based on the survival analysis. A Weibull parametric model for left, right and interval censored data allow to identify influent covariates for successive discrete thresholds of degradation. The criterion for deciding on the relevant information is based on the usual likelihood theory, as provided by likelihood ratio test or Wald test. The study is focused firstly on flexible pavement, because of their widespread use through the French network, secondly on two degradation processes (inseparable in the original database): base fatigue cracking and surfacing thermal cracking. The ultimate goal of the study is to evaluate the impact of maintenance on roads lifetimes.

Finally a mention is done about the difficulties that were encountered during the statistical analysis stage, particularly concerning the accuracy of the original data.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters :

- Did anybody experience survival models for correlated failure time data (marginal or frailty models), that means models taking into account the fact that several sections belong to a same road ?

- Did anybody experience survival models with unobservable (or latent) covariate(s)?

- How could we get a more informative longitudinal modeling, which means avoiding decomposition into successive thresholds of degradation?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

INTERPRETATION OF RUT DEPTHS FOR THE NORWEGIAN ROAD SURFACE PROFILER "ALFRED"

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ABSTRACT:

The road surface profiler ALFRED is scanning the Norwegian road network on a yearly basis, measuring rut depths and longitudinal evenness. Data statistics are transferred to a national road data bank, defining the data basis for pavement management systems. We are engaged in projects for the Norwegian Public Road Administration on how to measure and interpret the cross profile data to calculate rut depths, and how to use the data to design better PMS systems.

The Norwegian road network is very varying, and a lot of rural roads are quite narrow. This presentation will describe the current rut definition models used for the ALFRED equipment, and how the lane width determines the choice of algorithm. We will in particular discuss how to interpret ruts on narrow roads where the traffic in the opposite directions creates a shared central rut at the middle of the road.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matter:

- What is the best interpretation of rut depth on narrow roads where the traffic in the two opposite directions creates a shared central rut?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.