Systematic decision making processes within Bridge Management System

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Content

- Introduction
- BMS basic structure
- BMS in European countries
- Supporting materials and tools
- Previous projects (European, American)
- Deliverable D09
  - Recommendation
  - Conclusions
Introduction

- **WP2:**
  Structural Assessment and Monitoring (TUC, Spain, J. R. Casas)

- **Task 2.4:**
  Systematic decision making processes associated with maintenance and reconstruction of bridges (CDV, Czech Republic, J. Stryk)

- **Deliverable D09:**  
  August 2009
  Recommendation on systematic decision making ...
  
  - BMS in NMS
Bridge management system

- commercial / own system
- bridge-level / network-level

- condition & structure safety assessment of bridges
- information on costs & technologies
- decision on maintenance, repair, rehabilitation, strengthening and reconstructions
- prediction
- prioritization

- questionnaire (14)
- national reports (7)
<table>
<thead>
<tr>
<th>Country</th>
<th>Year of BMS starting</th>
<th>Prioritisation in BMS</th>
<th>No. of bridges managed</th>
<th>Used system/software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulgaria</td>
<td>2004/2005</td>
<td>No</td>
<td>1.312</td>
<td>Scan print-Freissinet</td>
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<tr>
<td>Croatia **</td>
<td>developed now</td>
<td>Yes</td>
<td>800 on highways</td>
<td>Oracle 10.G</td>
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<tr>
<td>Czech republic</td>
<td>2002</td>
<td>Yes</td>
<td>20.490</td>
<td>IIS database + MS SQL Server</td>
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<td>Estonia</td>
<td>2002</td>
<td>Yes</td>
<td>922</td>
<td>Pontis</td>
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<td>France *</td>
<td>1999</td>
<td>No</td>
<td>9.000</td>
<td>own system</td>
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<tr>
<td>Germany *</td>
<td>2000/2001</td>
<td>Yes</td>
<td>38.000</td>
<td>SIB-Bauwerke; BMS-Optimisation-tools</td>
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<tr>
<td>Hungary</td>
<td>1996</td>
<td>Yes</td>
<td>6.000</td>
<td>adapted Pontis</td>
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<tr>
<td>Italy *</td>
<td>1986</td>
<td>Yes</td>
<td>3.626</td>
<td>Oracle, SQL server</td>
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<tr>
<td>Latvia</td>
<td>2002</td>
<td>Yes</td>
<td>1.775</td>
<td>LatBrutus</td>
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<td>Serbia ***</td>
<td>1985</td>
<td>Yes</td>
<td>3.500</td>
<td>BPM</td>
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<tr>
<td>Slovakia</td>
<td>1998</td>
<td>Yes</td>
<td>7.664</td>
<td>Microsoft Access</td>
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<td>Slovenia</td>
<td>1992</td>
<td>No</td>
<td>2.300</td>
<td>UNIX</td>
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<td>UK</td>
<td>2001</td>
<td>Yes</td>
<td>8.600</td>
<td>Oracle</td>
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<td>Ukraine ****</td>
<td>2006</td>
<td>Yes</td>
<td>2.203</td>
<td>Microsoft Sql Server, Borland Delphi</td>
</tr>
</tbody>
</table>

* former EU members, ** candidate country, *** potential candidate country, **** membership possible
Basic structure of BMS

ADMINISTRATION MODULE
- users
- groups of bridges
- general settings

INVENTORY MODULE
- bridge:
  - description
  - elements
  - documentation
  - current condition
  - current load capacity
  - current serviceability

INSPECTION MODULE
- different types of inspections, testing, monitoring and modeling
- results of survey
- suggestion for change of condition and structural safety state

MAINTENANCE MODULE
- required activities
- carried out activities
- cost of activities
  - work codebook
  - cost catalogue

PRIORITY MODULE
- predictions:
  - degradation (aging)
  - failure risk
  - traffic
- analysis:
  - life cycle cost analysis (LCCA)
  - cost benefit analysis (CBA)
- prioritization:
  - choosing the best strategy

deterioration models
budget

bridge (project) level

network level
Bridge level & network level

- **bridge level**
  - condition assessment - rating of elements or structure
  - safety assessment - load carrying capacity, safety factors
  - economical optimisation (LCCA)
  - measures/activities with their urgency

- **network level**
  - state, regional or other programs and priorities
  - social and environmental consequences
  - prioritization of activities within limited budget
  - bridge priority list
Supporting materials and tools

- **Deterioration models**
  - for the whole bridge / its elements
  - based on inspections, experience and prediction
    - creation of bridge categories
    - determination of residual lifespan

- **Catalogue of defects**
  - identification of potential origins
  - anticipation of further progression
  - measures and their urgency

- **Cost catalogue**
  - for appropriate estimation of future agency costs

- **Traffic grow models**
  - to evaluate future load and requirements
Determination of costs

- **Agency costs**
  - design, construction, inspection, maintenance and operation of a bridge, rehabilitation and replacement costs
    - known costs from realized activities
    - determined by qualified estimate

- **Road user costs**
  - time costs
  - vehicle operating costs
  - accident costs
    - from traffic delays
    - connected to traffic detours

- **Other costs**
  - vulnerability costs
  - third party costs
  - environmental costs
Bridge LCCA

- bridge level
  - planning horizon
  - different strategies
    - do nothing
    - MR&R (in more variants)
    - total reconstruction
  - calculation of costs
    - agency
    - user
    - other (vulnerability)
  - optimisation from economical point of view

- calculation of costs
  - agency
  - user
  - other (vulnerability)
BRIME decision system, 2000

Global **cost function** $C$:

$$C = C_C + C_I + C_M + C_R + C_F + C_U + C_O - V_S$$

- $C_C$: construction costs
- $C_I$: inspection costs
- $C_M$: maintenance costs
- $C_R$: repair costs
- $C_F$: failure (vulnerability) costs
- $C_U$: road user costs
- $C_O$: other costs
- $V_S$: salvage value of the bridge

Repair/replacement decision is made according to **repair index** $RI$ of each alternative:

$$RI = \frac{(C_I + C_M + C_R + C_F + C_U + C_O - V_S)_{\text{Repair or replacement}}}{(C_I + C_M + C_F + C_U + C_O - V_S)_{\text{No action or reference alternative}}}$$
European and American projects

Bridge Management of Europe, **FP4, 1999**  
[www.trl.co.uk/brime/index.htm](http://www.trl.co.uk/brime/index.htm)

Procedures required for the Assessment of Highway Structures, **COST, 2002**  
[http://cost345.zag.si/](http://cost345.zag.si/)

Sustainable and Advanced MAterials for Road InfraStructure, **FP5, 2006**  
[http://samaris.zag.si/](http://samaris.zag.si/)

Structural Assessment Monitoring and Control, **FP5, 2006**  
[http://www.samco.org](http://www.samco.org)

Bridge Life-Cycle Cost Analysis, **USA, 2003**  

Multi-objective optimization for bridge management systems, **USA, 2007**  
Deliverable D09

- Bridge management system
  - Structure of BMS
  - Supporting materials
  - Cost categories
  - Bridge life cycle cost analysis
  - Decision making processes within BMS

- State of the art
  - Literature review - reports
  - Literature review - conference paper
  - National reports (7 countries - CZ, SK, BG, LV, EE, IT, FR)
  - Questionnaire survey (14 countries)

- Recommendation on BMS & conclusions
Recommendation

- **Connection of BMS to current system**
  - based on current assessment processes used in the country
  - develop own system / buy commercial software
  - preferred usage of internet application

- **Structure of BMS**
  - the basic structure of the BMS should be as follows:
    - administration module
    - inventory module
    - inspection module:
      - condition assessment - condition rating
      - structure safety assessment - evaluated load carrying capacity
    - maintenance (financial) module:
      - determination of costs
    - prioritization (optimisation) module
Recommendation

- Decision making processes within BMS
  - bridge (project) level (LCCA) / network level (multicriterial analysis)
  - short-term planning and long-term planning
  - deterioration models & planning horizon & cost categories

- Asset management
  - connection of BMS with PMS, tunnel MS and management systems of other assets
BMS in the Czech Republic

Basic information are public through internet:  http://bms.vars.cz

- inventory data
- description of substructure & superstructure
- condition & load carrying capacity
- schemes, documents
- inspections
- maintenance
- net present value (NPV)
- optimization module
- location (map)
Conclusions

- BMS is a basic tool for optimal planning of maintenance/repair/replacement of bridges.
- Most countries prefer usage of their own developed BMS or at least adjusted commercial BMS.
- BMS is useful even in case of limited resources for MR&R.
- For optimal BMS functionality you need enough correct data.
- The planning could be based on sufficient bridge assessment.
- Uncertainties in BMS processes should be minimised.
- The importance of other than agency costs on decision making process must be clarified.
- Each system is as good as people who work with it.
Thank you for your attention.

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