

Science Summary: SCHO1205BKAW-E-P

Condition Monitoring and Asset Management (CMAM) for Complex Infrastructure Systems

Background to R&D project

The CMAM project addresses the science underlying the management and modelling of complex systems such as a coastal cell or reach of a river. It was motivated by the recognition that basic research on the representation of complex infrastructure systems for issues such as multi-attribute decision making, process modelling, condition characterisation, reliability analysis and uncertainty handling was not easily used by flood and coastal defence practitioners, or even modellers. In particular, new thinking in systems management had failed to have a significant impact on industry practice in flood and coastal defence and the related river and coastal management activities. Dr Jim Hall and colleagues at University of Bristol obtained an EPSRC grant to carry out research to produce a more clearly applicable methodology to flood and coastal management, and to hydropower generation. The research was steered by a group of seven industrial partners, including a major UK dam owner (Scottish and Southern Energy) and the Environment Agency as the lead authority for flood defence. These latter two organisations supported two dedicated PhD studentships and provided access to practical cases within their own organisations.

Results of R&D project

The research developed a new methodology for modelling the performance of complex infrastructure systems. This not only addresses specific technical issues but considers how these collectively contribute to overall organisational and business performance. The methodology merges hierarchical modelling of processes, multi-attribute measurement of performance and uncertainty handling with interval probabilities.

The performance modelling methodology has been implemented in a software tool called Perimeta. Perimeta combines a hierarchical process modelling tool with a database of performance indicators and an inference engine for propagating uncertain information through the hierarchy. Whilst other industrial sectors have seen an immediate use for this software, the time and resource involved in constructing process models of flood management systems preclude its adoption within the Agency at this time. However the software and concepts will prove useful for subsequent development work on management systems for flood defence assets.

The research on condition characterisation recognised that the Agency has only limited information on which to make efficient decisions about investment in maintenance and upgrading of its defences. It therefore sought to establish how scarce and imprecise information could be used to inform judgements of system performance and decision making. The approach adopted was to use imprecise probability and fuzzy sets to construct imprecise conditional failure probability distributions for system components.

A case study was undertaken addressing the flood defence system for the town of Burton upon Trent. The model included both structural and non-structural (e.g. flood warning, public awareness raising and development control) flood management measures. One of the objectives of the study was to demonstrate how a process model could include all of the individual flood defences and components that are the focus of every day operations and maintenance activities. The Perimeta model provided a coherent overview of the whole complex system and an indication of its performance at a range of levels. It also provided an indication of the sources and implications of uncertainty and provided a platform for testing potential interventions in the system, in particular illustrating the impact of improving the condition grade of defences.

R&D Outputs and their Use

The principal outputs are a summary report, a PhD thesis and the Perimeta software. There is also the intellectual knowledge that has been developed, synthesised and disseminated by the research team. This is probably the biggest contribution of the CMAM project, as the “systems-based, hierarchical” approach to the management of flood and coastal defences is now well embedded in Defra and Agency strategy (e.g. the Agency’s new Flood Risk Management Strategy) and into emerging practice (e.g. flood management plans).

Some of the detailed knowledge about how best to represent a complex system and to deal with uncertainty and incomplete information on the state of the component assets will feed into the work on Performance Based Asset Management System (PAMS). This is a major “step change” project that will draw together a range of new techniques to enable management decisions on has been identified through the O&M Concerted

The concepts that were developed in this research informed the ICE Presidential Commission on Flooding and are embedded into its report on *Learning to Live with Rivers*. They also feed into Defra’s new Flood & Coastal Defence Project Appraisal Guidance Note 6 on Performance Evaluation.

This R&D Technical Summary relates to R&D Project W5A-042 and the following R&D outputs:

- **R&D Technical Report W5A-042/TR – Condition Monitoring and Asset Management for Flood and Coastal Defence Systems.** Published August 2003 (this is a reproduction of a report submitted to EPSRC by Dr Jim Hall at University of Bristol)

Publication Internal Status: Released Internally External Status: Released to Public Domain

- **PhD Thesis on Performance-based management of flood defence systems** Submitted by Richard Dawson to the University of Bristol in May 2003.
- **Perimeta Decision Support Software** Available through Dr Jim Hall at the University of Bristol

A copy of the thesis will be lodged for reference with the Agency’s National Library and Information Service and will be made available to internal staff wishing to view it. For other external interests normal thesis loan arrangements from the University of Bristol will apply. Requests for information on the Perimeta software should also be directed to the University of Bristol through the Department of Civil Engineering and Dr Jim Hall.

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Research Contractor: Department of Civil Engineering, University of Bristol
<http://www.cen.bris.ac.uk/civil/>

Technical Report W5A-042/TR is available on the Defra / Environment Agency R&D webpages (www.environment-agency.gov.uk/floodresearch). Copies are held by all EA Regional Information Centres and can be purchased from the Environment Agency’s R&D Dissemination Centre, c/o WRc, Frankland Road, Blagrove, Swindon, Wiltshire SN5 8YF (Tel: (+44) 1793-865012; Fax: (+44) 1793-514562; email: publications@wrplc.co.uk).

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