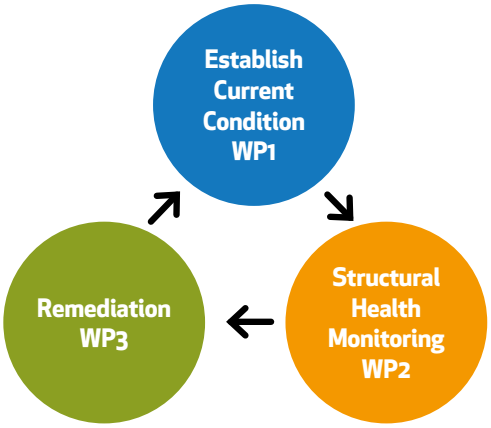
# SMART MAINTENANCE AND ANALYSIS

**FEHRL's Design and Production Systems (DPS) Research Area, jointly led by Alan O'Connor (TCD) and Jos Wessels (TNO), focuses on the methods and processes of infrastructure from a cost, efficiency and harmonisation perspective. On the next pages, we profile three projects currently underway within DPS – SMARTRAIL, TRIMM and INROADS. While SMARTRAIL is a good example of FORx4 and FEHRL carrying out research in the railway mode, TRIMM focuses on the implementation of advanced monitoring techniques in Road Asset Management (within the FOR Adaptable Road Element) and INROADS is part of the FOR Automated Element to develop intelligent road studs containing lighting.**


SMARTRAIL, the 36-month FP7 project to carry out the Smart Maintenance and Analysis of Transport Infrastructure, has made significant progress since it was first profiled in the first edition of this magazine last year. The project, which has now been running for just over two years, considers the effect of climate change on ageing rail infrastructure across Europe and was developed in response to a number of incidents which occurred on the European rail network, including the collapse of the Malahide viaduct in Ireland and the failure due to scour of the railway bridge over the river Sava in Zagreb, Croatia.

*Failure of railway bridge pier in Zagreb, Croatia (31st March 2009)*

In order to achieve the SMARTRAIL concept, the following critical and interdependent elements are required: an embedded sensor network, state of the art Structural Health Monitoring (SHM) and a suite of low-cost remediation measures that are region-specific. These are addressed with the project's five Work Packages (WPs), which aim to establish the effective monitoring of the current condition of railways (WP1), predict the future condition of infrastructure and improve the efficiency of maintenance programmes (WP2), verify sustainable technologies for effective rehabilitation (WP3) and quantify cost and benefit (Life-Cycle Analysis/Life-Cycle Condition (LCA/LCC) (WP4) and WP5 dissemination and exploitation.

Within WP1, a range of measures are being implemented to allow infrastructure owners to move away from reliance on visual inspection methods towards more reliable and efficient techniques, including embedded sensor networks to monitor stress, strain, water pressure etc. Wireless embedded sensor networks are being deployed to monitor the in-situ state of critical infrastructure elements such as bridges, soil slopes and tunnels. As a demonstration project, a full-scale experiment was performed on an instrumented railway embankment in Ireland to measure the effect of a prolonged artificial rainfall event on the slope stability. A steep railway slope built in the 1850's was instrumented with sensors to measure soil suction and water content and subjected to approximately two years of rainfall over a one-week period. The measured effects of water inflow and the consequent reduction in soil strength, and therefore factor of safety measured, are being used to calibrate infiltration and reliability based safety assessment procedures.


*Typical rainfall induced failure of steep slopes (a) embankment (b) Cutting*

# OF TRANSPORT INFRASTRUCTURE

In WP2, meanwhile, degradation models for materials are being improved through the development of degradation models for ballast using in-situ measurements (with input from WP1). Finite element analyses, laboratory and field testing are being used to achieve these aims. The new models will be implemented in SHM analyses. A demonstration project is underway in Poland, where a bridge-weigh-in-motion monitoring experiment has been undertaken on a steel railway bridge, the Nieport Bridge. The sensors are currently being adapted to allow for remote sensing to take place. Models are under development to undertake the real-time reliability based structural safety analysis of the bridge.


*Sensor-equipped railway bridge in Poland*

Deterioration models for ballast, soil and concrete will also be developed in WP2. These models, which will examine the response to cyclic loading, will be used in SHM models that allow engineers to make rational evaluations of the probability of failure of elements of infrastructure. The probability of failure increases with time and planned interventions can be optimised to allow best use of resources.

Optimum renewal methods for each region are being evaluated in WP3, where regional solutions are needed as soil conditions, construction techniques and the availability of raw materials varies regionally. Demonstration projects include the rehabilitation of the transition zones for the Buna Bridge in Croatia[1]. The old bridge has been transported to the structures laboratory at IGH in Zagreb, where it will be remediated and tested to destruction.

WP4 is dedicated to providing an asset management tool that can collate the input data from WP1 to WP3 and information from databases collated by the infrastructure managers to perform whole LCA, which will include the evaluation of the full-cost and effect of remediation actions.

WP5 (dissemination and support of exploitation) aims to provide practical and innovative solutions from the customer's point of view using questionnaires, interviews and bilateral meetings. This ensures that the work is focussed on the needs of the end-users and, more importantly, will be implemented in practice. The project has held sessions at major conferences including TRA2012, the CETRA 2012 Conference, Innotrans 2012, the FEHRL Infrastructure Research Meeting 2013 (FIRM13) in June 2013, the European Transport Conference (ETC) in September 2013, the UNECE Trans-European Railway Workshop and Transport Days in Bucharest, October 2013.

▶ For more information on SMARTRAIL, see **www.smartrail.fehrl.org** or contact Dr. Kenneth Gavin at kenneth.gavin@ucd.ie.

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[1]*Covered in p.17 of SMARTRAIL article in the November 2012 issue of this magazine.*