A Multi-objective Optimisation Model for Sewer Rehabilitation

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The Challenges

- Ageing water infrastructure in the UK
- Historic lack of under-investment
- Oldest assets located in our busiest areas
- Failures lead to direct customer impact, eg, flooding & pollution
- Customers demand higher and higher levels of service

The Questions

Conventional sewerage rehabilitation relies on the expertise of engineers to manually evaluate CCTV survey data when determining the nature and extent of the rehabilitation solutions. This is a tedious and subjective process that has no quantifiable means of identifying optimal solutions. Therefore, a number of unanswered questions remain…

- Does the solution offer the greatest structural improvement ?
- Is the solution the most cost effective solution available ?
- Does the solution present the highest value to the customer ?

The Process

1 Optimisation model (1) identifies an array of low cost vs. high benefit solutions for each individual sewer from the raw CCTV inspection data.

2 The array of possible engineering solutions for each individual asset, ranging from isolated patch repairs to full lining solutions, are present to the user for review. The engineering review process removes technically non-feasible solutions from the 2nd phase of optimisation.

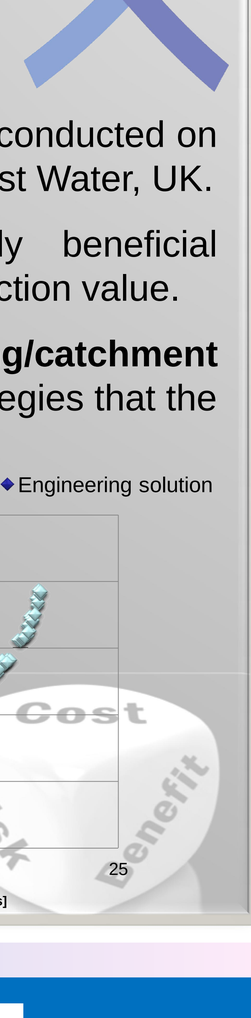
3 Optimisation model (2) performs catchment wide optimisation to prioritise the remediation of assets causing serviceability problems. An automated hot-spot analysis is performed in GIS [within the model] to quantify serviceability benefits.

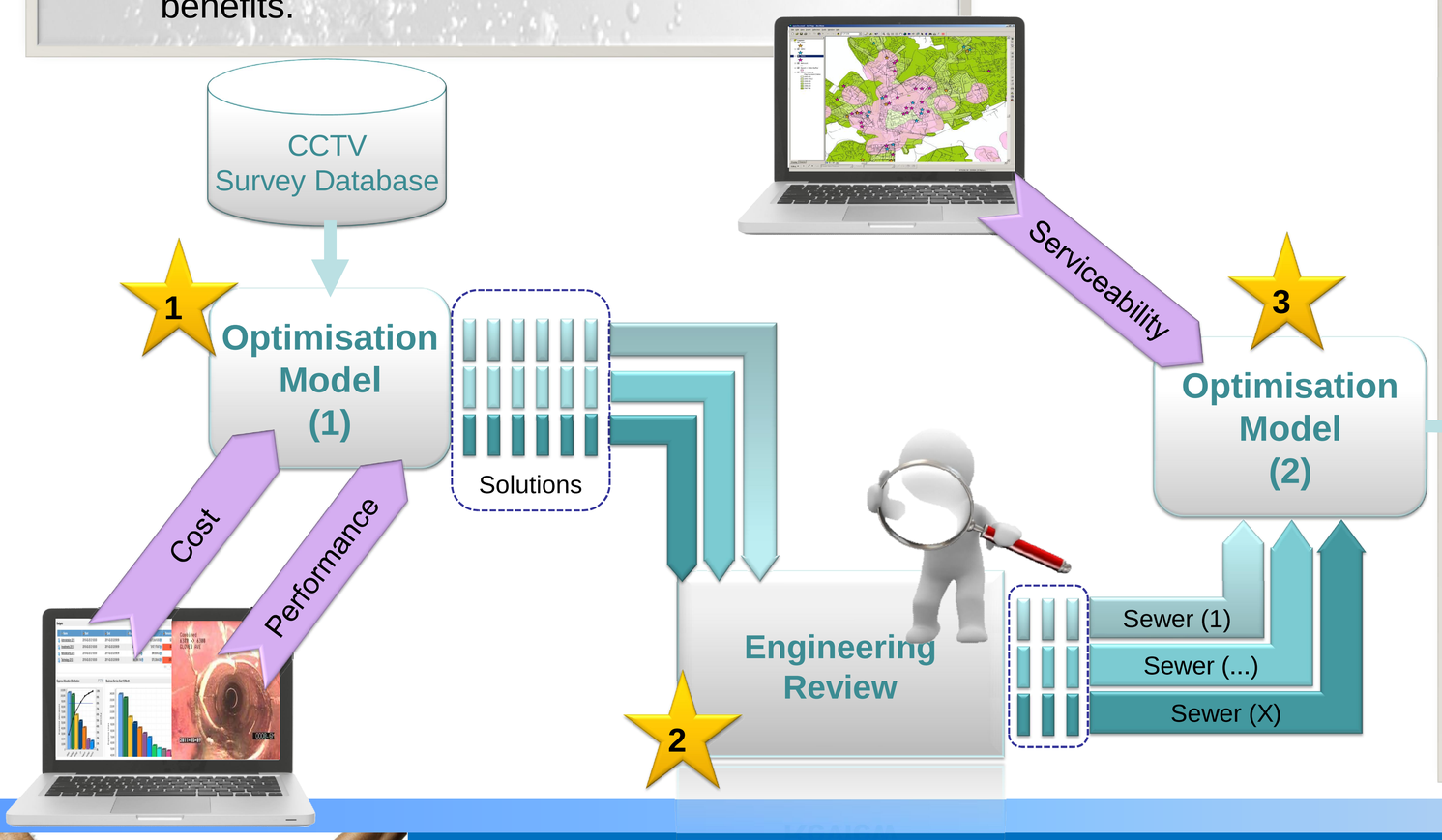
The Theory

A data management and optimisation environment has been developed to answer these three questions that are associated with the specification of optimal sewer rehabilitation strategies.

In order for a multi-objective genetic algorithm to be applied to the problem of optimal sewer rehabilitation specification, a decision environment is used to formulate the problem in-terms of: objective functions; decision variables; and constraints. Where-by the objective functions take the form of: 1) Cost Minimisation, 2) Network Condition Improvement, *and* 3) Network Serviceability Improvement.

A well established Genetic Algorithm optimisation tool developed by the University of Exeter, GANetXL, is applied to the problem – giving astonishing results.



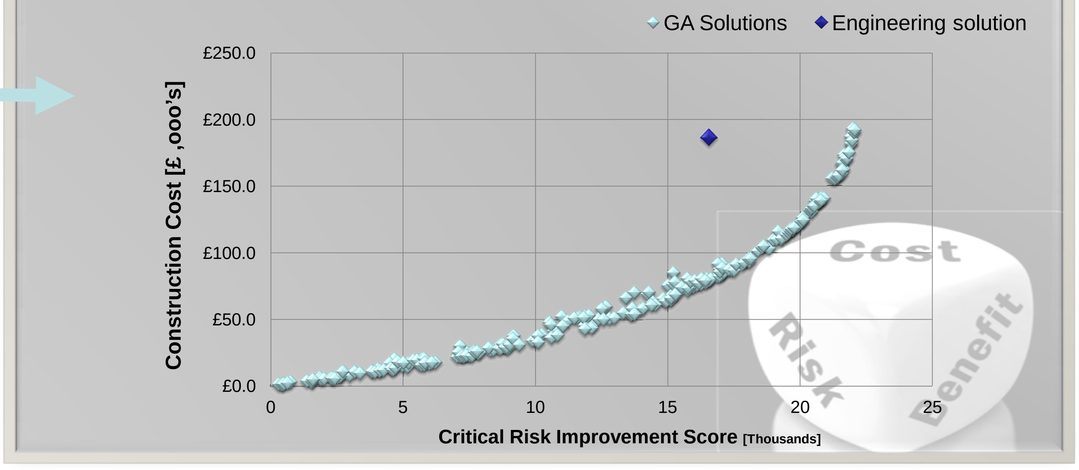


The Results

An appraisal of the models effectiveness was conducted on a catchment case study provided by South West Water, UK.

The optimisation model identified equally beneficial solutions for approximately 50% of the construction value.

This equates to approximately **£100,000 saving/catchment** and an array of truly optimal rehabilitation strategies that the user can select from; below.



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Further reading : Ward,B and Savic, D. A (2012) . A Multi-objective Optimisation Model for Sewer Rehabilitation. Water Science & Technology, 66(11), 2410–2417.