FROM ASSET TO NETWORK: GRAPH-BASED OPTIMISATION OF INTERDEPENDENT MAINTENANCE DECISIONS FOR TRANSPORTATION NETWORKS

ABSTRACT Conventional maintenance decision-making in transport asset management has traditionally concentrated on optimising individual projects, determining when interventions should occur and what type of treatment should be applied. While such approaches can be effective for isolated schemes, they often fail to capture the complex interdependencies that exist between projects within a wider transport network. These interdependencies can significantly alter traffic flow, capacity, and reliability, resulting in unintended redistributions of network performance and, in some cases, inefficient allocation of resources. Recognising these limitations, this study proposes a portfolio optimisation framework designed to explicitly account for project interdependencies and thereby support more resilient network-level decision-making.

The proposed framework combines mathematical optimisation techniques with graph convolutional network modelling, which is well-suited to representing topological relationships across transport networks. By embedding network structure into the optimisation process, the approach enables planners to assess trade-offs across multiple projects simultaneously, rather than treating each project in isolation. This integrated perspective allows decision-makers to consider both direct project impacts and indirect network-wide effects.

To demonstrate its applicability, the framework was tested on a real-world urban road network comprising over 2,000 road sections and maintenance projects scheduled across a 15-year horizon. The results show that the proposed approach can reduce cumulative maintenance costs compared with conventional single-project optimisation, while improving overall network performance indicators. Furthermore, the coordinated scheduling of interdependent projects was found to mitigate performance bottlenecks, distribute traffic load more evenly, and enhance the efficiency of budget utilisation.

The study concludes that considering project interdependencies is critical for developing resilient transport strategies. By offering a robust and scalable basis for long-term asset management planning, the framework provides practitioners with a decision-support tool that aligns cost efficiency with network resilience.