DEVELOPMENT OF A DECISION SUPPORT SYSTEM USING A CRITICAL INFRASTRUCTURE INTERDEPENDENCY MODELLING FRAMEWORK

Syed Yasir Imtiaz[1], Raj Prasanna[1], S R Uma[2], Kristin Stock[3] and Denise Blake[4]

[1]Joint Centre for Disaster Research, Massey University, Wellington, New Zealand
[2]GNS Science, Avalon, Wellington, New Zealand
[3]Institute of Natural and Mathematical Sciences, Massey University, Auckland, New Zealand
[4]School of Psychology, Massey University, Wellington, New Zealand

MOTIVATION

This research aims to develop a computer-based simulation framework to model interdependencies between electricity and road infrastructure networks. The simulation framework uses damage information of significant infrastructure components of the electricity network and applies an integrated research methodology to determine optimum repair sequencing for the damaged components included in the tree structure.

FUNCTIONALITY OF AN ELECTRICITY NETWORK

Wellington's metropolitan power supply is provided from the generation units via a hierarchical system of 220kV, 110kV, 33kV, 11kV and 400V network components. Transpower New Zealand supply a series of grid exit points (GXPs). From here onwards, Wellington Electricity (WE*) controls the supplies to commercial and domestic customers. Different GXPs are connected with each other through high power 110kV cables passing through transmission structures, the supply from GXPs to substations is connected through 33kV overhead or buried sub-transmission cables.

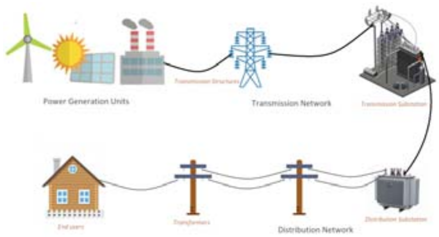


Figure 2 Architecture of an Electricity Network

INTEGRATED LINKING METHODOLOGY

We have developed an integrated research methodology for using one of the models as a subset of the other model. As shown in the central figure of this poster, both the models have their specific inputs and outputs. Road network model is integrated into electricity network model as a subroutine in such a way that electricity model uses the outputs of road access times between various road zones to give some realistic restoration times.

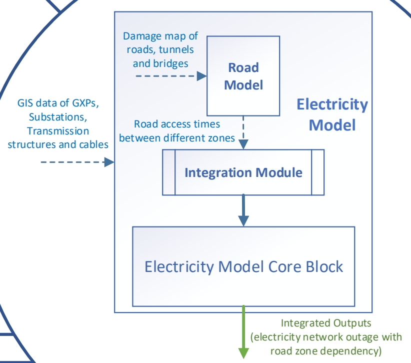
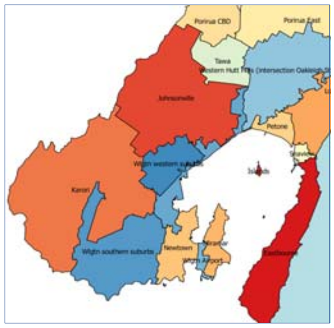


Figure 1 Integrated Linking Methodology

ELECTRICITY AND ROAD NETWORK ZONE MAPS

ELECTRICITY SUBSTATION ZONES



ROAD ACCESS ZONES

Figure 3 Electricity and Road network zone maps of Wellington region

MODELLING ASSUMPTIONS

- Scope of this test case is to model only the electricity transmission network. For the distribution network, a predefined number of recovery days are assumed.
- The repair times for various cable types could be different because some of them could be solid fluid-filled and are hard to repair.
- If the number of damages exceeds a predefined value, then the repair work of the cables could be abandoned and replaced with emergency overhead lines based on substation's on top priority list.
- The road outage times would be computed based on the assumed number of days between different road zones.
- Every component of electricity network would be mapped over a predefined road zone to understand the additional amount of road access time to reach the site before starting the repair work.

OUTAGE MAPS OF DIFFERENT TIMESTAMPS

- The outage maps on the right side show a comparison of recovery times of electricity substation zones with and without road dependency.
- We can see that in figure 4(a) where we have the road dependency, the electricity substation zones take longer time to recover as compare to figure 4(b) when there is no dependency on the road network.

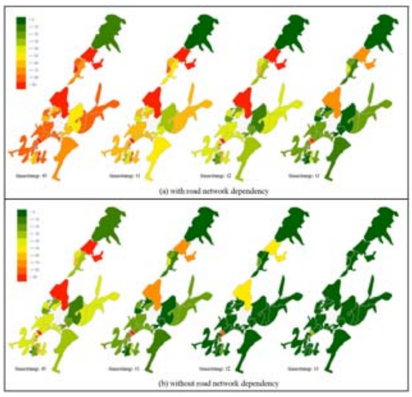


Figure 4 Comparison of timestamped outage maps showing the recovery times of Wellington's substation zones (a) with and (b) without road dependency

FLOWCHART OF THE MODELLING ALGORITHM

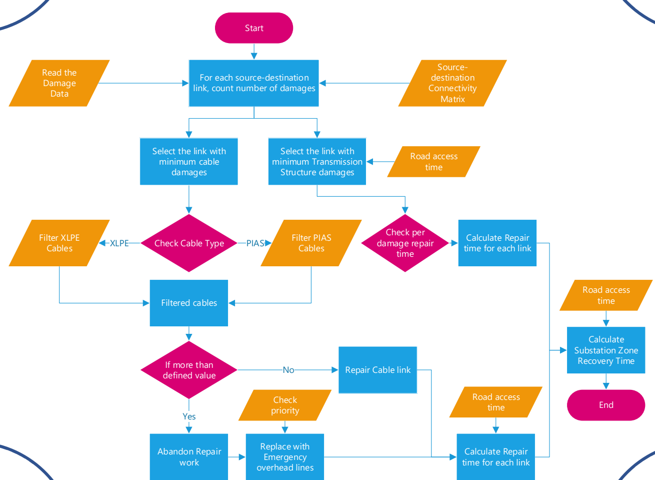


Figure 5 Flowchart of the modelling algorithm

Contact: y.syed@massey.ac.nz Joint Centre for Disaster Research (JCDR), Massey University, Wellington, New Zealand