A KNOWLEDGE-CENTERED DECISION SUPPORT SYSTEM USING AN INTEGRATED IMPACT ASSESSMENT FRAMEWORK FOR INFRASTRUCTURE NETWORKS

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RESEARCH AIM

The aim of this study is to design and develop a Knowledge-Centered Decision Support System (KCDSS) using a computer-based integrated impact assessment framework. The framework assesses functionality of Critical Infrastructure (CI) networks by modelling their interdependencies.

To achieve this, the KCDSS provides a convenient and efficient platform to run several 'what-if' scenarios and to generate respective results for consideration in decision-making processes. The features of the KCDSS and its capabilities are demonstrated through a set of real infrastructure networks from the Wellington region by analysing network performance independently and with interdependencies to generate outage of services in spatial and temporal aspects. The capabilities of the KCDSS are versatile enough that the utility providers from local government and private sectors will be able to make informed decisions to address the likely impact of infrastructure network failures provides various optimization options and scenario-driven comparative analysis through customizable CI asset recovery strategies.

INTEGRATED IMPACT ASSESSMENT FRAMEWORK

We have developed an integrated impact assessment framework for estimation of recovery times of individual networks based on their dependencies on the other networks.

The road zone data has been integrated with topology and damage data at the component level to include the respective access time, along with component recovery time to calculate the aggregated recovery time.

Figure 1 shows a linkage between the modelled CI networks along with different GIS diagrams of the supply zones of the three modelled networks. These diagrams also show the modelled components and their connecting links.

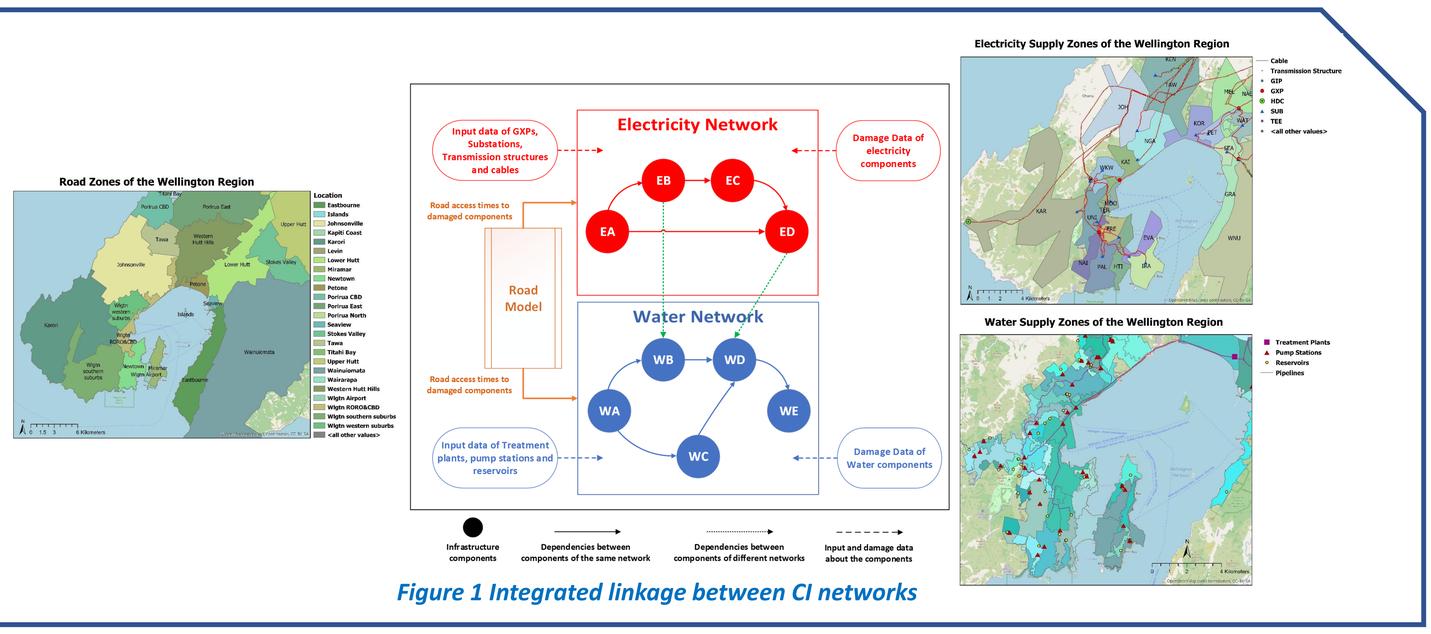

Figure 1 Integrated linkage between CI networks

MODELLING ASSUMPTIONS

- Scope of this test case is to model only the electricity transmission and potable water networks along with the road access times.
- The repair times for various component types is different because of the variety of their structure. An example of such a case are electricity solid fluid-filled cables that are relatively difficult to repair as compared to other cable types.
- If the number of electricity cable damages exceeds a predefined value, then the repair work will be abandoned and these cables will need to be replaced by emergency overhead lines based on the interconnected substation's on top priority list.
- The road outage times are computed based on the estimated number of days between different road zones.
- Every component of electricity and water network is mapped over a predefined road zone to estimate the additional amount of road access time to reach the site before starting the repair work.

FLOWCHART OF THE MODELLING ALGORITHM

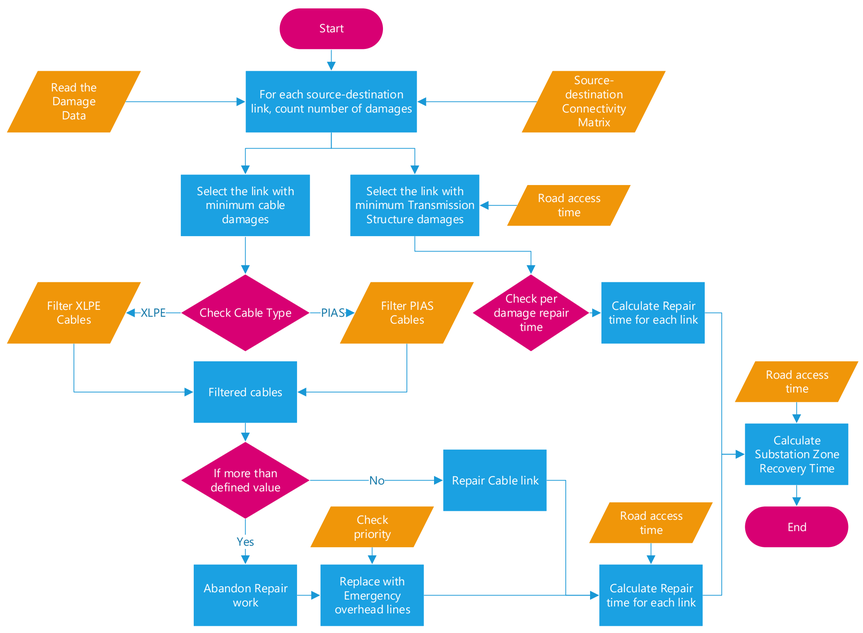

Figure 2 Flowchart of the different steps of the modelling process

KCDSS ARCHITECTURE

Presentation tier	Business logic tier	Data tier
User interface layer	**Application Processing Layer**	**Data and knowledgebase layer**
Front-end for the Decision makers	Application and Web server containing ASP.net engine, C# Source code and JavaScript files	Database server containing the database, knowledgebase and the DBMS
	Web Server *Application Server*	Database *Database Server*
View module of the MVC	**Controller** module of the MVC	**Model** module of the MVC

Figure 3 A three-tier client-server software architecture of the KCDSS

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.

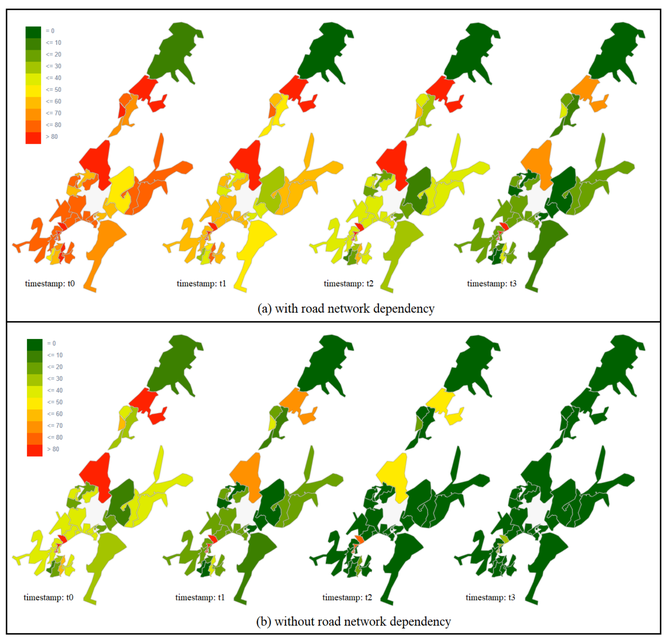

Figure 4 Comparison of timestamped outage maps showing the recovery times of Wellington's substation zones (a) with and (b) without road dependency

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