# Vulnerability and Resilience Assessment of the New Zealand Telecommunication Infrastructure

## The case of the 2011 Christchurch Event

**Silvia Bertelli**
silvia.bertelli@ucl.ac.uk
Supervisors:
Dr Sonia Giovinazzi
Rob Ruiter
Dr Susana Lopez-Querol
Dr Liam Wotherspoon
Prof Tiziana Rossetto

**University College London**
**Department of Civil, Environmental & Geomatic Engineering**

## 1. Introduction

New Zealand, one of the most natural disaster-prone countries in the world, is regularly subject to **high-intensity earthquakes, and its co-seismic events** such liquefaction and landslides, inflicting loss of lives and costly damage to the country's infrastructure (Figure 1 and Figure 2).

The **performance of the telecommunication** networks is of high priority as it has a substantial impact on our lifestyle during business-as-usual times.

Their **operational robustness** becomes even more **critical** in a post-disaster scenario when these services are used in civil protection and emergency plans, as well as for the restoration of all the other critical infrastructure. Despite the relevance of loss of functionality of telecommunication networks on seismic resilience, studies on their performance assessment are few in the literature.

*Figure 1 – Damage to a roadside cabinet in Christchurch (Courtesy of Chorus).*

*Figure 2 – Liquefaction inside ducts in a manhole observed during the inspections after the CES (Courtesy of Chorus).*

## 2. Aims & Objectives

The main aim of the current project is to develop a comprehensive and systematic risk assessment framework for the New Zealand Telecommunication Network.

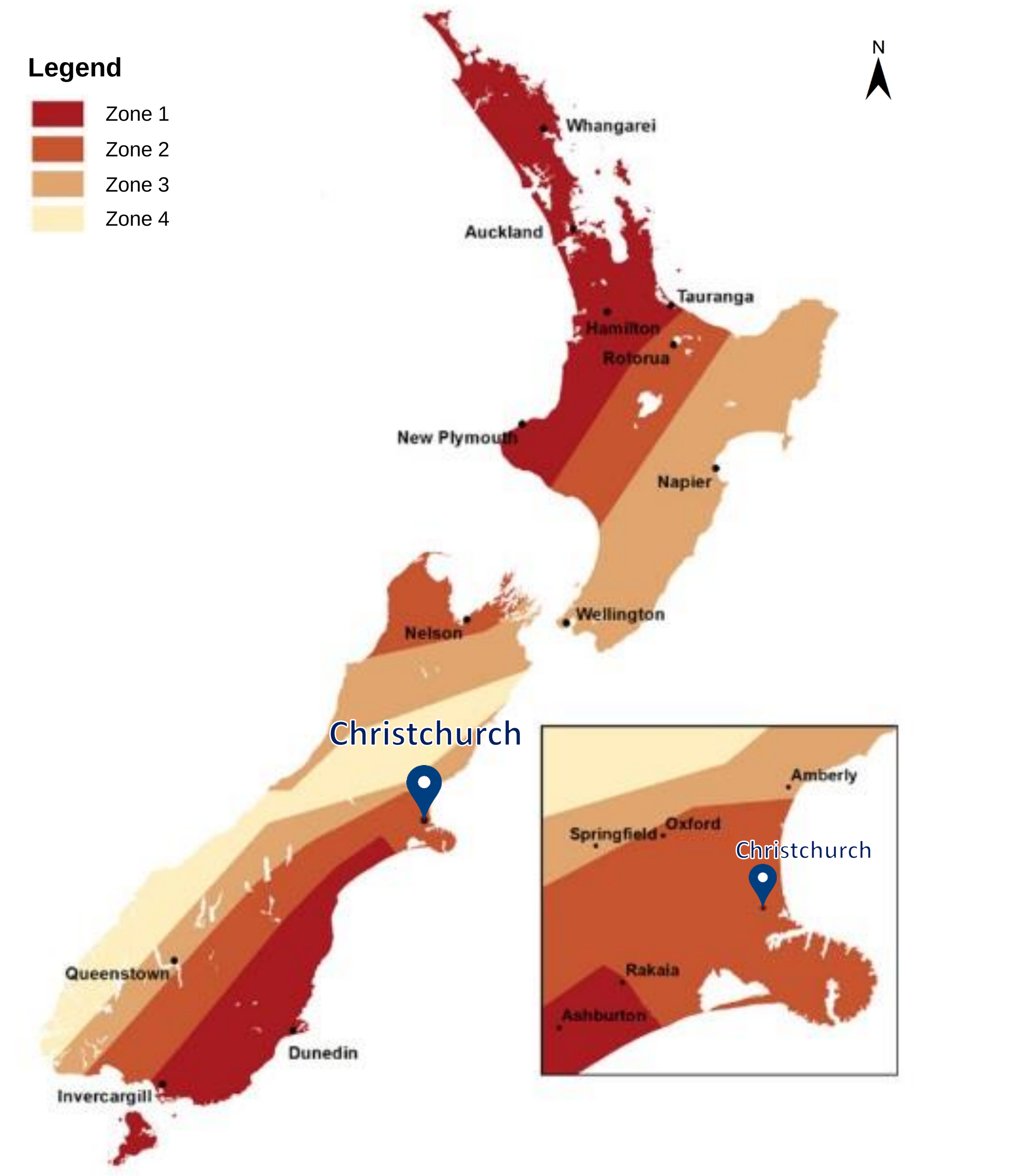


*Figure 3 – New Zealand Seismic Zonation Scheme. These zones are modified versions of those in Figure 5.4 of NZS 3604:2011 to better align with NZS 1170.5:2004, Structural design actions- Earthquake actions – New Zealand and recent rezoning of the Canterbury region. (BRANZ, n.d.)*

As part of the project:

- Data and information related to the physical damage and functional impacts suffered by the various components of the Telecommunication System during the **Christchurch 2010-2011 earthquake sequence (CES)** are processed.
- A methodology is developed for the **collection of information** and the subsequent assessment of the networks' performance.
- **Information gaps** are critically identified regarding physical and functional failures of the various components, the timeline of repair and reconstruction activities and service recovery.
- **Practical improvements** in the post-disaster collection from both a network and organisational viewpoints are proposed to increase the resilience of the system.

## 3. The New Zealand Telecommunication System

The telecommunication infrastructure is it comprised of two main networks, the **landline** and broadband data service network, and the **wireless cellular service network**. These are linked together by means of data interoperability and transmission exchanges, made in turn of different components including among others, underground cables, access pits, roadside cabinets, overhead lines and poles, cellular towers, exchange facilities.

Locally, the New Zealand telecommunications infrastructure is mainly based of **interconnected fibre-optic network**, while the copper networks are still in place but are increasingly being replaced.

Given that these networks **cover a large geographical area**, they can be easily subjected to the effects of a seismic event, either the ground shaking itself, or co-seismic events such as liquefaction and landslides.

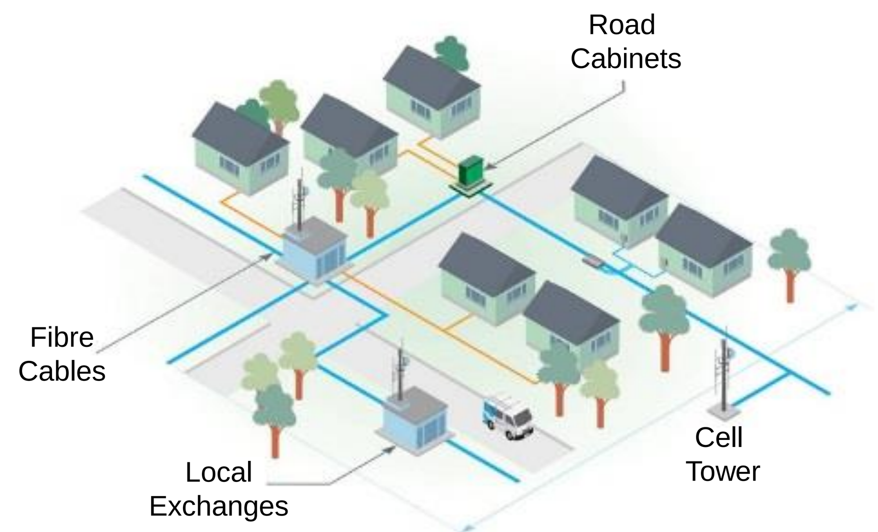


*Figure 4 – Schematic structure of the telecommunication network in New Zealand ( Courtesy of Chorus)*

## 4. Data Collected

Telecommunication Data were acquired for the main components of the telecommunication network of Christchurch City, namely: **Exchange buildings, Roadside cabinets, Fibre Cable, access pits** including **vaults** and **manholes**. Table 1 provides an overview of the data made available by Chorus for each of these components and investigated after the CES.

In order to have a better understanding of the telecommunication network system, telecommunication data collected in the aftermath of the event including all the missing components, such as aerial cables and piles, SCADA Equipment and copper cables, have been requested to different providers and are in the process to be analysed.

### References

Tang et al. (2014) Telecommunication Systems' Performance: Christchurch Earthquakes. *Earthquake Spectra*. Vol.30, No 1, pp.231-252.

Giovinazzi et al. (2018). Seismic Fragility of Telecommunication network. *Research Project DPC-RELUIS 2014-2018 Technical Report and Deliverables*. Rete dei Laboratori Universitari di Ingegneria Sismica.

BRANZ (n.d.). Earthquake risk zones. Seismic Resilience. From: http://www.seismicresilience.org.nz/topics/seismic-science-and-site-influences/faults/earthquake-risk-zones/ (Last access: 26/06/2018)

## 5. Hazard Representation

The most damaging earthquake of the **CES** was the **Mw= 6.2** which stroke the city of Christchurch on the **22 February 2011** (Tang et al., 2014). Thus, this event is the one that has been taken into consideration in the analyses.

The city and its telecommunication infrastructure network was strongly impacted by an **unprecedented level of liquefaction**. This was mainly observed through the southern and eastern suburbs of Christchurch alongside the main river that flows through the city.

**Figure 5**, adapted from the one provided by the New Zealand Geotechnical Database, shows the property liquefaction severity, based on visual observations from roads.

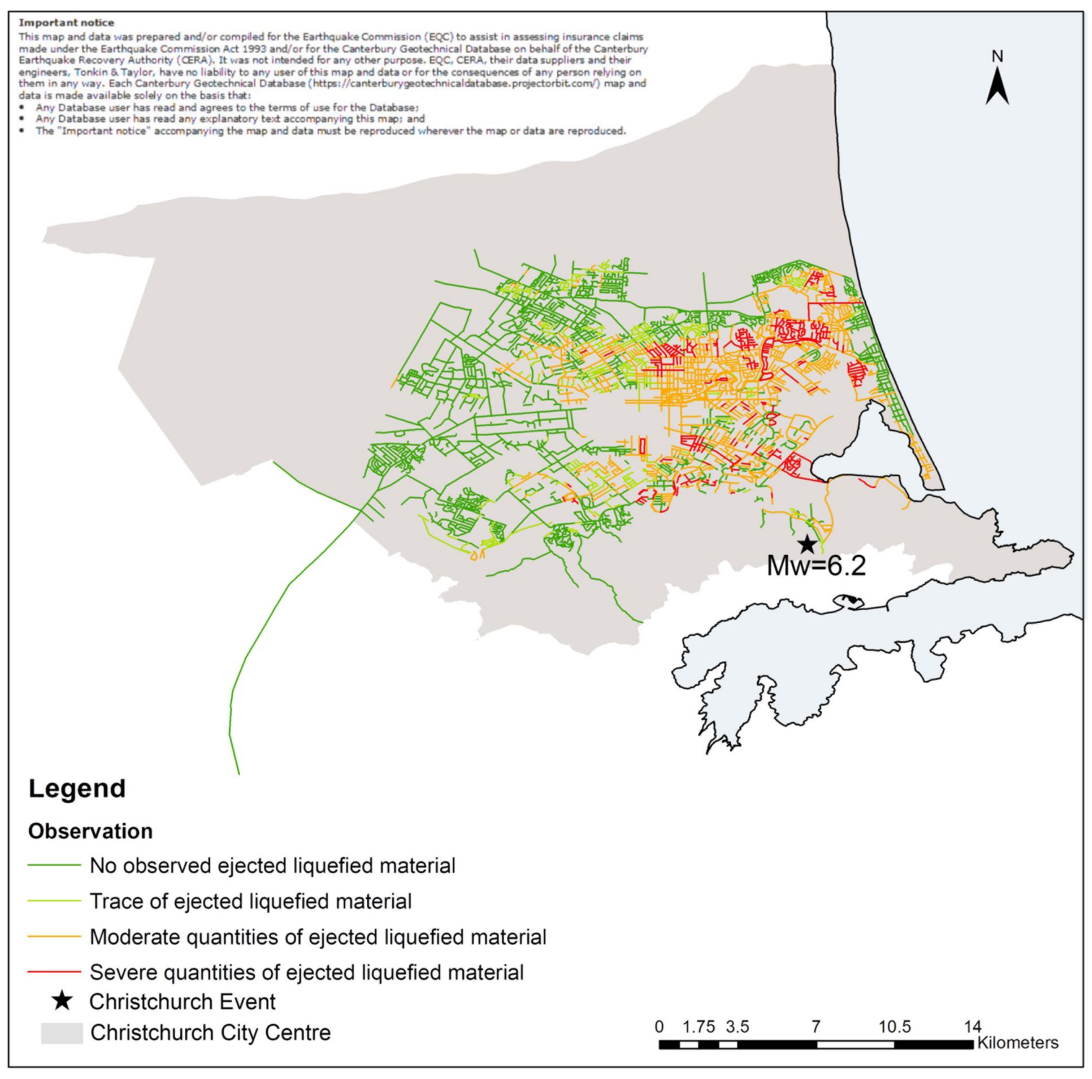


*Figure 5 – GIS Layout of Fibre Cables, Road Cabinets and Exchanges in Christchurch inspected after the CE (Adapted from NZGD).*

## 6. Data processing

Data collected are processed in a **Geographic Information System** (GIS) environment, given that the software facilitates cross-referencing operations between different information. If the locations are known, it is possible to attribute to each component of the telecommunication system a seismic intensity measure (PGA, Sa, PGD) and liquefaction level. Thus, it is possible to correlate the observed damage to the corresponding seismic impact.

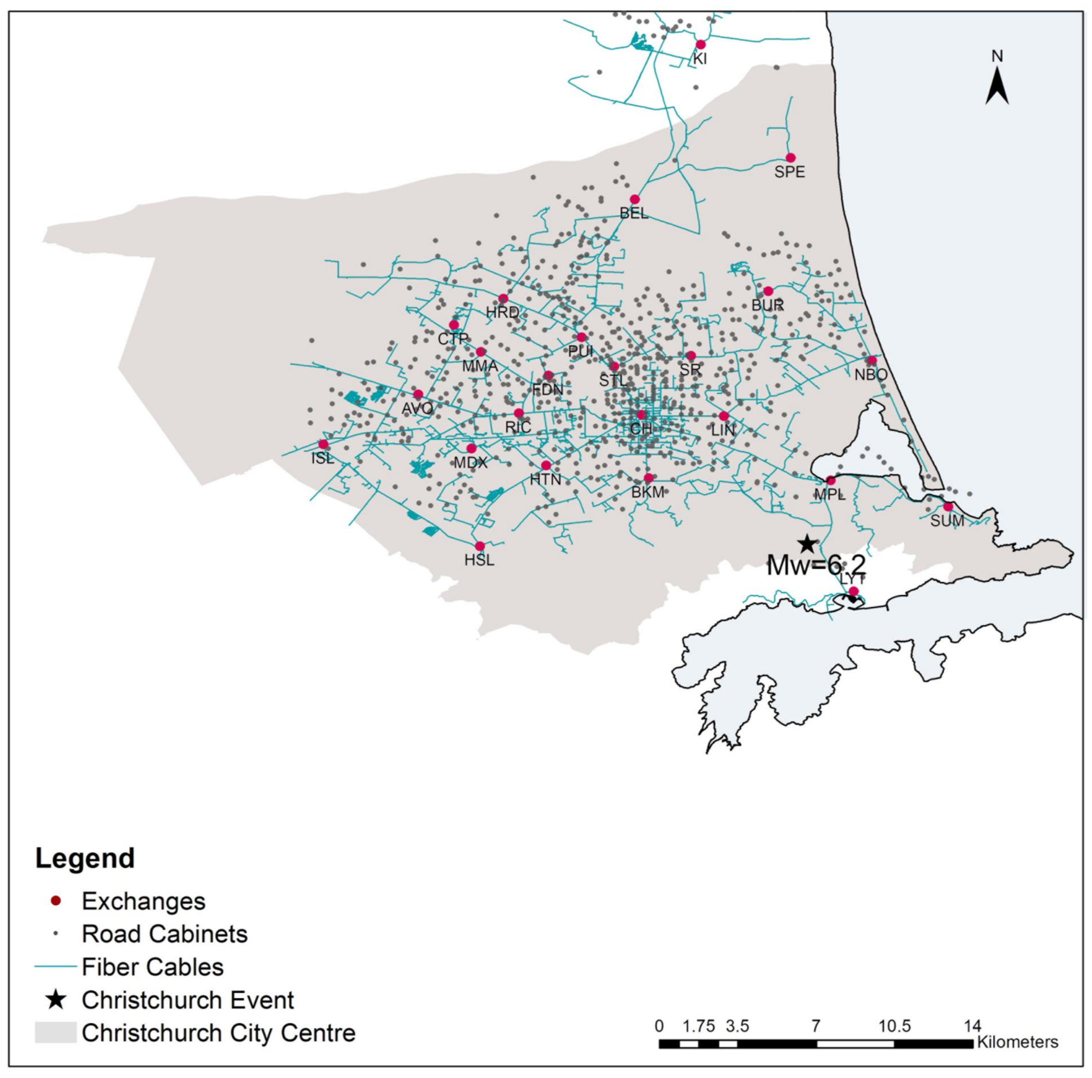


*Figure 6 – GIS Layout of Fibre Cables, Road Cabinets and Exchanges in Christchurch inspected after the Canterbury Earthquake.*

As illustrated in Table 1 and Figure 6, this operation has been performed for the Exchanges, Roadside cabinets and Buried cables for which the **geographic coordinates** are known.

The introduction of a **quantitative damage description** is desirable. The assignment of damage level required some interpretation, given that in the available data, if this information was provided, it was a general qualitative description.

It will be worth further investigation in **design detail of each component** to distinguish any particular trends. For instance, useful information would be dimensioned, age of construction, material, constructive details, seismic design level, and also time and cost required to repair.

*Table 1– Type of data acquired for the telecommunication components and supplementary information to further resolve the impact on the network system.*

| COMPONENTS | DATA | AVAILABLE DATA | FURTHER INFORMATION |
|---|---|---|---|
| Exchanges Buildings | ✓ | GIS location; Site inspection from the CES | Building type structure and damage, repair time and cost |
| Buried Cables | ✓ | GIS layout of Fibre network with number of cables | Cable type, fault type, fault location, cost and reparation time |
| Roadside Cabinets | ✓ | GIS location | Design Information, Temperature, Cables, Repair Cost and Time, damage type |
| Access pits (manholes & vaults) | ✓ | Manholes and Ducts investigation observation from CES (Size, Damage description, Cost) | GIS location, Quantitative Damage Assessment and Fault Distance, Material, Repair Time |
| Poles | ⌛ | ⌛ | GIS Location, Design & Damage Information, Repair Cost and Time |
| Aerial Cables | ⌛ | ⌛ | GIS Location, Design & Damage Information, Repair Cost and Time |
| Cellular Towers | ⌛ | ⌛ | GIS Location, Design & Damage Information, Repair Cost and Time |
| SCADA Equipment | ⌛ | ⌛ | GIS Location, Design & Damage Information, Repair Cost and Time |

## 6. Outcomes Expected & Future Steps

Even though the effect of the CES' lessons from **the performance of the 2010/11 system** have already been implemented in the new telecommunication network, which will be more resilient to future hazards, the present project aims to provide a further step for increasing the system resilience. In particular, it will:

- Detailing the geotechnical assessment to understand the **influence of liquefaction** on the infrastructure network;
- Proposing **fragility models** for different components of the telecommunication networks;;
- Investigating the **inter-dependencies** with other infrastructure systems.

The obtained results from the project will allow providers to quickly identify the most vulnerable components among the surveyed stock, guide more detailed data collection and assessment procedures, and ultimately plan further retrofitting measures or if necessary replacement.

QuakeCoRE NZ Centre for Earthquake Resilience Te Hiranga Rū
CEGE DEPARTMENT OF CIVIL, ENVIRONMENTAL & GEOMATIC ENGINEERING 190 YEARS ENGINEERING A BETTER WORLD
EPICentre
EPSRC Pioneering research and skills