RESILIENT CRITICAL INFRASTRUCTURE

Resilience of critical infrastructure to natural hazards

The negative effects of natural disasters are mainly caused by a failure or disruption of the **critical infrastructure (CI)**. The European Union (EU) define CI as assets, systems and parts thereof, which are "*essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact*" (Art. 2, Council Directive 2008/114/EC). Some important subsectors are the power and water supply, as well as transportation. Due to their importance, CI shall be highly protected, regardless of their sensitivity or vulnerability.

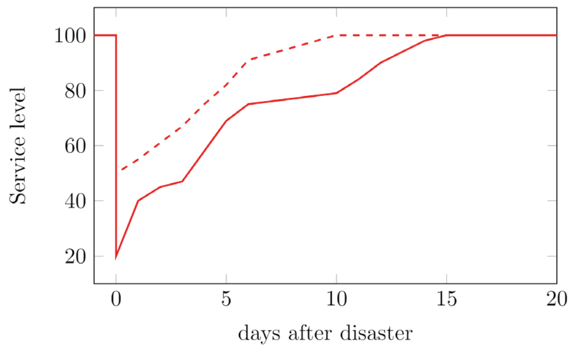
Chilean harbors such as San Antonio (picture) and Talcahuano, have been affected by natural hazard events such as the 1985 and 2010 earthquakes. Photo: Hugo Rosero, March 2019.

THE CONCEPT OF RESILIENCE

The consequences of a natural Hazard on CI are not limited to the physical damage of the systems. A prompt reparation and service resumption also reduce the consequences.

Based on the definition provided by Bruneau et al. (2003, in Earthq Spectra, 19(4): 733-752) a resilient system shows:

- **Reduced failure probability**
- **Reduced consequences** associated to failures, in terms of damages, fatalities, and negative socioeconomic impact
- **Short recovery time**

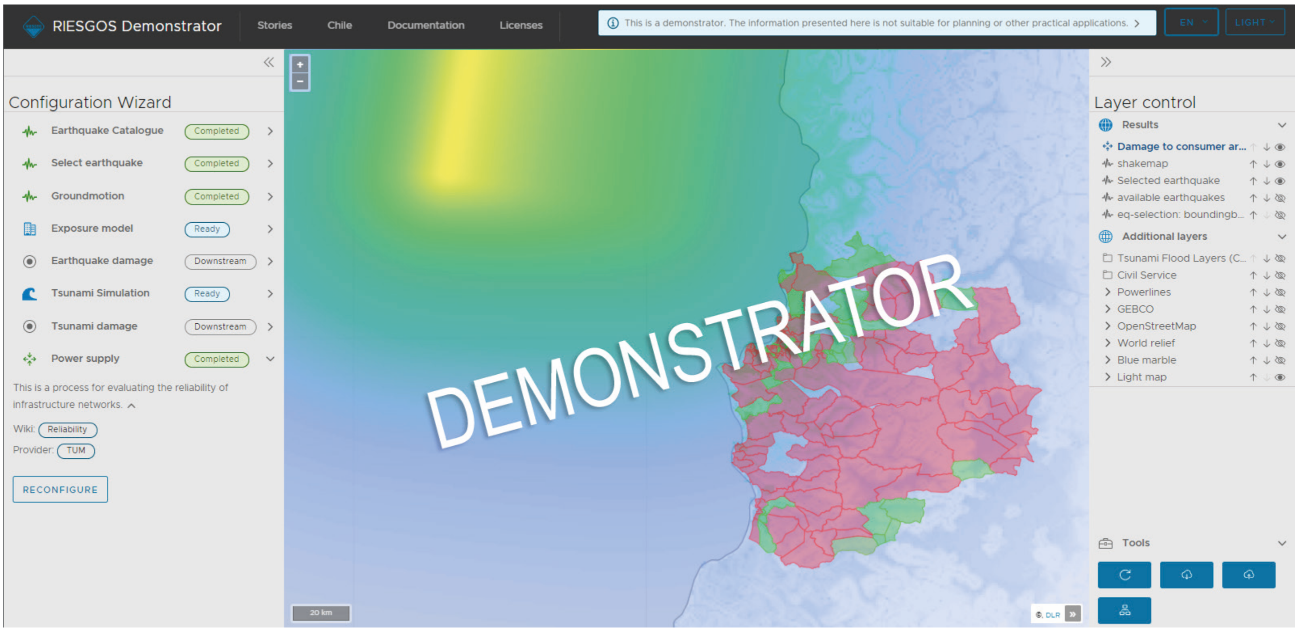


Conceptual definition of resilience for critical infrastructure. The dashed line represents a more resilient system than the one represented by the continuous line.

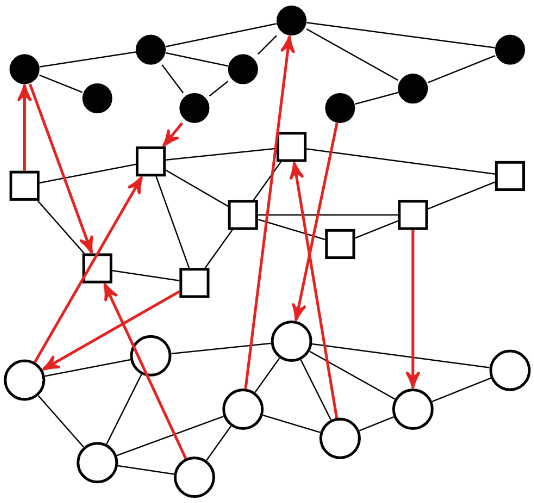
NETWORKED SYSTEMS, DEPENDENCIES AND CASCADING EFFECTS

The functional relation among the CI components can be represented in a simplified manner with a network. CI is constantly changing. It is common that the systems have mutual dependencies.

Therefore, the failure of one component can trigger failures in other components and systems, hence producing a cascading effect.



Visualization of a multi-risk scenario for the Valparaíso region (Chile). The areas potentially affected by power supply disruption are shown in red.



Exemplary representation of three networked systems. The arrows indicate dependencies between components of different networks.

In complex systems with large number of components, there are several possible failure mechanisms, and evaluating each of them for identifying representative scenarios is impractical. However, Crucitti et al. (2004, in Phys Rev E, 69, 045104R) proposed a generic model that simulates cascading effects and Scherb et al. (2017, en ASME J. Risk Uncertainty Part B, 3(2):021007) applied it for reliability analysis of power networks.

PILOT REGIONS

The **RIESGOS** project has implemented for the pilot regions of Valparaíso (Chile), Lima and Callao (Perú) and Cotopaxi (Ecuador) a web service that simulates the affectation of CI due to disaster scenarios. Currently only the power network is implemented. The demonstrator can perform a Monte Carlo simulation for computing the probability of disconnection for each distribution system. This result can be related with census data for estimating the potentially affected population by a blackout.

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More information about the project:
www.riesgos.de

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