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Decision Support System for Infrastructure Network Vulnerability to Natural Disaster

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Abstract

In a high industrialization context, our societies depend more and more on networks such as power grid, water, gas and telecommunications systems. The number and the variety of events such as snowfall in Paris in winter 2010, or the tsunami in Japan in March 2011 demonstrated the infrastructures' vulnerability against natural disasters. In addition the various materials, services, energies and information exchanged may aggravate or mitigate the consequences. Because of the interdependencies, the malfunction of a network's entity is likely to spread to the others; to a scale exceeding one of a country, making difficult any risk analysis.

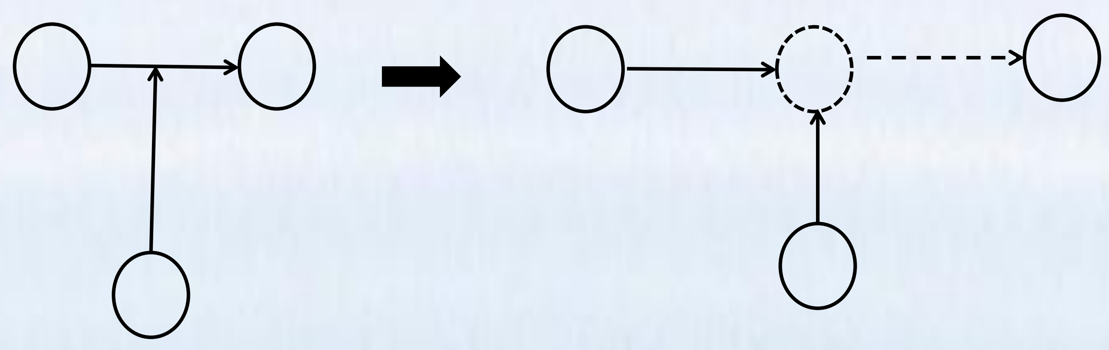
The VESTA project aims to propose a methodology of analysing infrastructure network risk and vulnerability in the field of prevention or reduction of the natural disaster consequences. This model will lead to a decision support system multi-view, multi-stakeholder, and communication's protocols in crisis situation.

Scientific issues

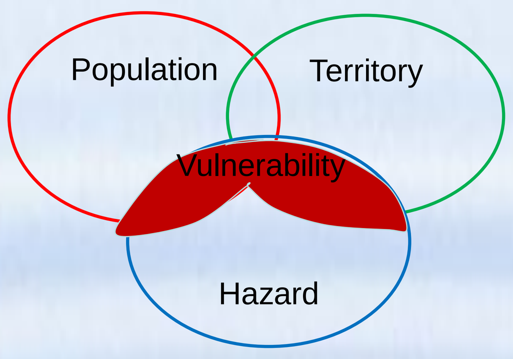
- Modelling interdependent critical infrastructure,
- Modelling risk,
- Modelling interdependences,
- Structural and functional vulnerability analysis,
- Correlation between hazard's intensity and damage to the stakes,
- Design of a decision support system for disaster management.

Methods

- Relation identification
  - Influence
  - Dependence
- Interdependence modelling



Vulnerability sets



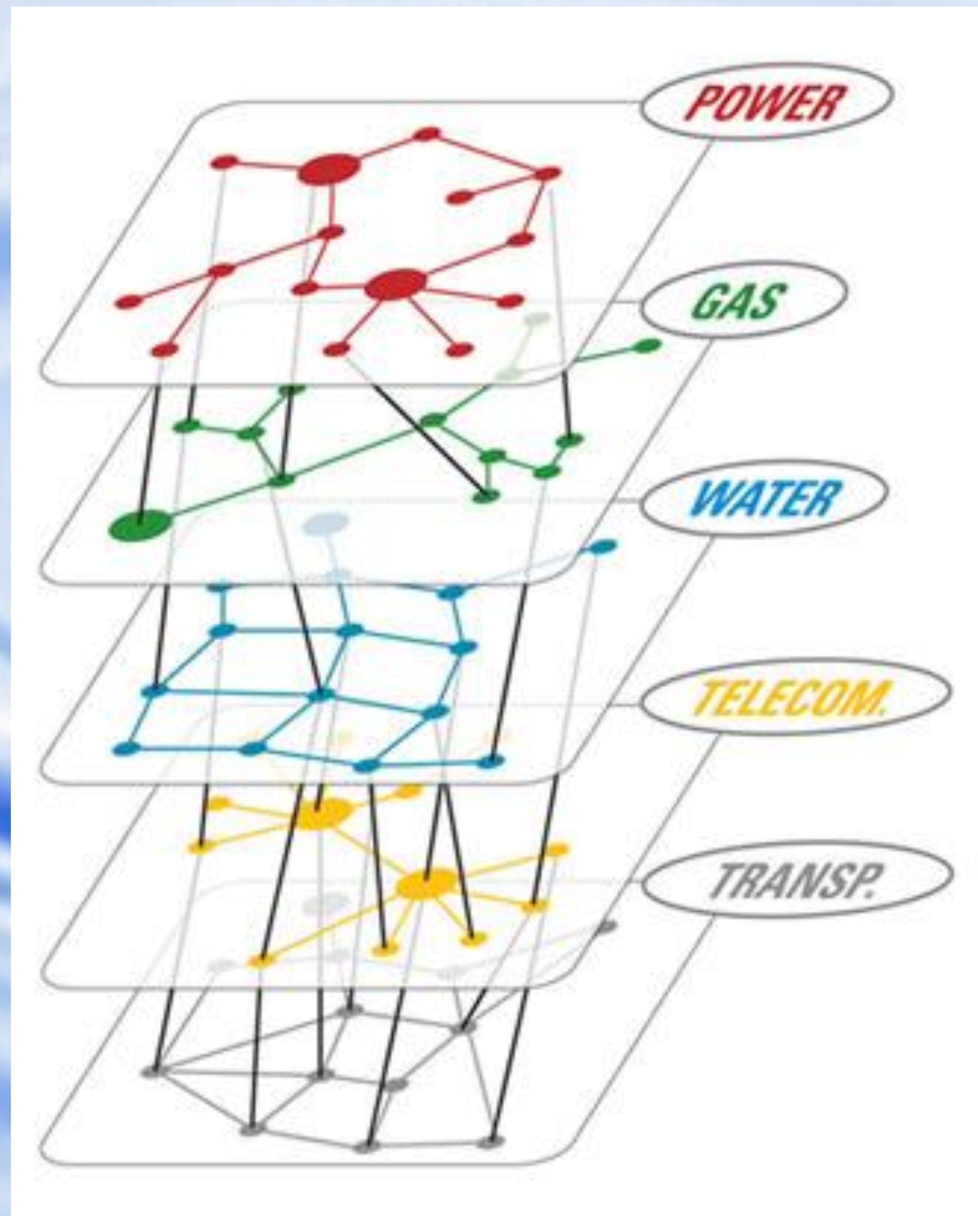


Illustration: Leonardo Dueñas-Osorio -quoted by Ref 7

Vulnerability assessment

$$V = P(Hazard) \times \vartheta$$

ϑ is the overall vulnerability induced by network components

$$\vartheta = 1 - \prod_{n=1}^{N} (1 - \vartheta_n)$$

ϑ_n is the vulnerability of component n

$$\vartheta_n = (1 - R_b)(1 - R_s)$$

R_s is the robustness and R_b is the resilience.

$$R_s = 1 - \frac{t_2}{t_1}$$

t_2 is the cumulated time of the improper functioning states while t_1 refers to the good running ones

$$R_{bi} = R_{bsi} \times R_{bdi}$$

R_{bdpi} is the dynamic robustness resulting of the combination of a flow p transiting through a component i

R_{bsi} is the structural robustness of the component i

$$R_{bsi} = \frac{N_{2i}}{N_{1i}}$$

N_{1i} is the failure rate before the feared event while N_{2i} is that after the feared event

$$R_{bdpi} = 1 - \frac{|C_{p2i} - C_{p1i}|}{C_{p1i} + C_{p2i}}$$

C_{p1i} is the component i consumption in flow p before the feared event and C_{p2i} it consumption after the feared event.

Vulnerability is "a stake's inability to resist the hazard's occurrence and to recover effectively it nominal functioning for a given period of time"

Results

- **Network vulnerability**
- **Territorial vulnerability**
- **Component type vulnerability**
- **Stake vulnerability**
- **Flow vulnerability**
- **Vulnerability induced by interdependences**
- **Worse Scenarios**

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