Resilience of Infrastructure Networks

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Resilience of Infrastructure Networks

Cost effective hazard prevention, mitigation and emergency response

Infrastructure Networks	**Causes of Disasters**
• Railway • Road/Highway • Water • Oil/Gas pipelines • Electricity • Internet • Air transport	• Typhoon • Floods • Meteor strike • Landslides • Earthquakes • Human made (e.g., human error, computer hacking, terrorism or military attack)

Fukushima Daiichi nuclear disaster (March 2011)

Source: http://www.veteranstoday.com

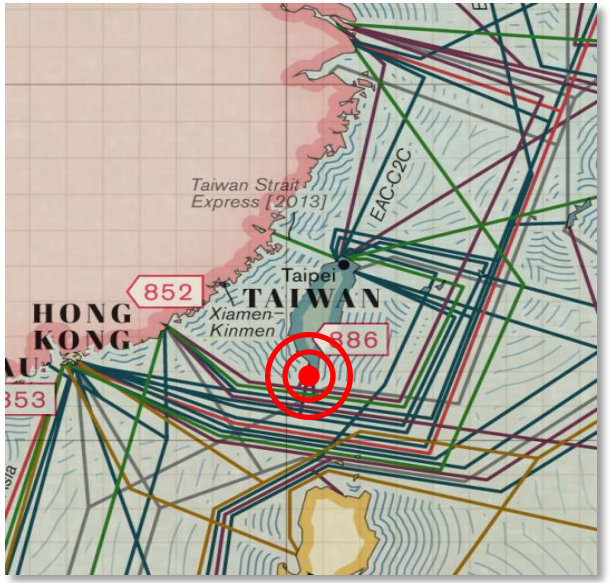
Source: http://www.eqclearinghouse.org

A Japanese parliamentary panel: "It was a profoundly man-made disaster - that could and should have been foreseen and prevented."

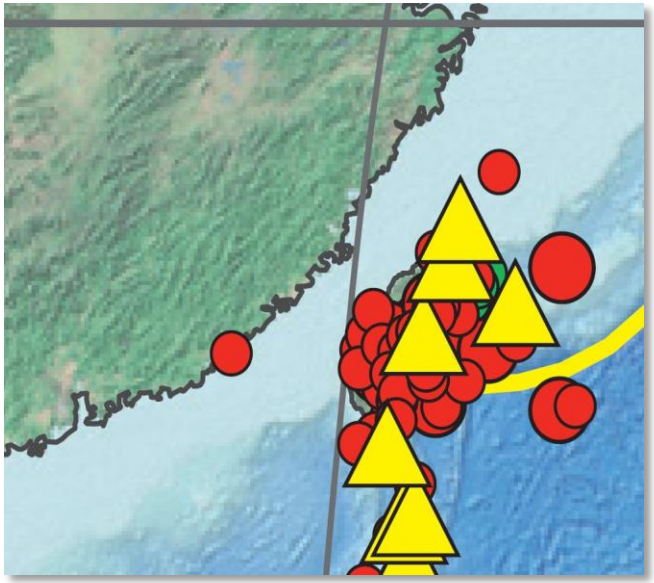
Source: http://www.bbc.com/news/world-asia-18718057

- Many lessons learned **after** the incident.
- New research on infrastructure resilience in Japan.
- We need science to guide us how to prevent or mitigate disasters – **before** they strike.

Hengchun (Taiwan) Earthquake 2006

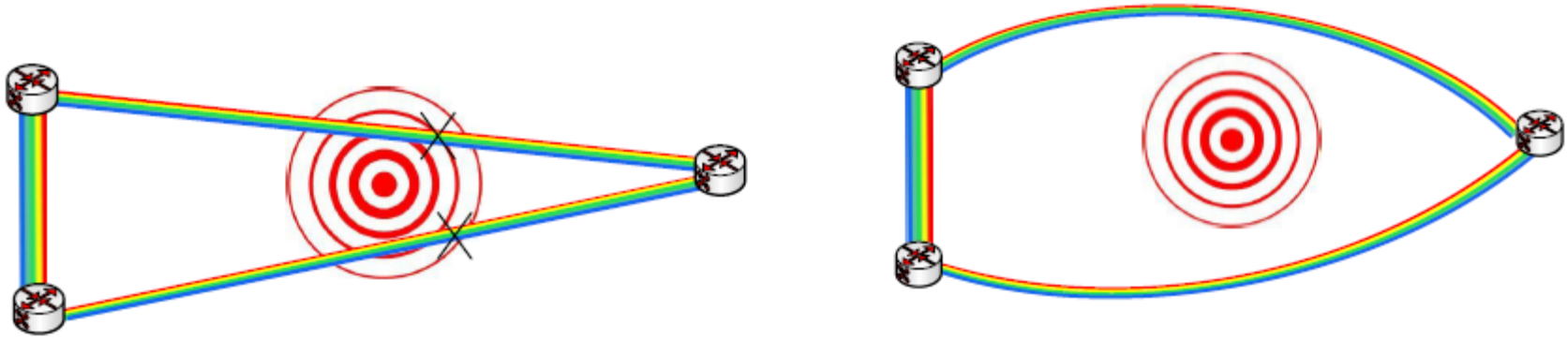


Credit: TeleGeography



Credit: U.S. Geological Survey

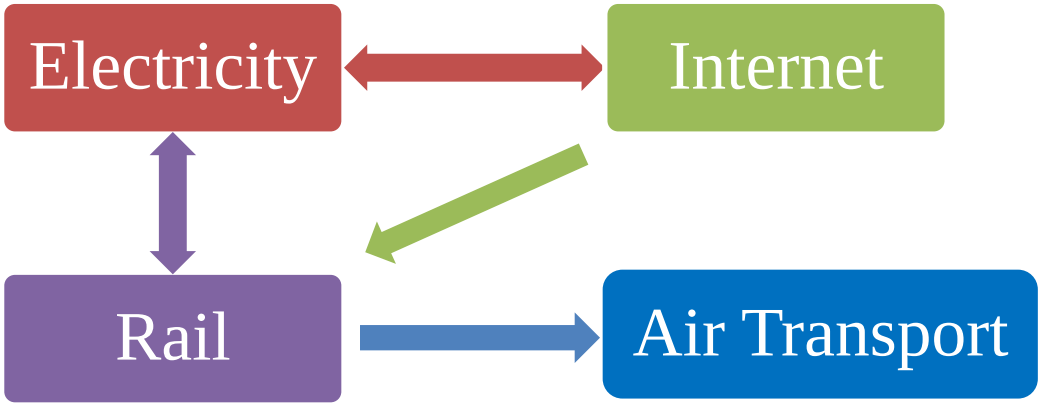
- Severe disruption of Internet and phone services in south east Asia (for several weeks from 26-Dec.)
- Switzerland – (ETH 2005) – reduction of **over 1% GDP** per week of Internet blackout.
- Loss of billions of dollars in China and HK if happens today.
- Demonstrates that HK is vulnerable to disasters in the region - need for collaboration with neighboring areas (especially Mainland).



- Curving cables (telecommunications, oil, gas) can improve network resilience.
- But it is more expensive.
- The interest of the government and the public may conflict with interest of individual companies.
- Optimizing the shapes of such cables considering earthquakes and topography – CRF scope.
- Optimizing Infrastructure planning considering all possible disasters, all infrastructures and their interdependence – TRS scope.

Cascading failures in infrastructure networks

<u>A possible scenario</u>: electricity failure causes Internet failure, which in turn causes failure in power stations (as in Italy 2003). Then, both may cause failures in the rail network and the trains cannot deliver oil to power-stations and airplanes.

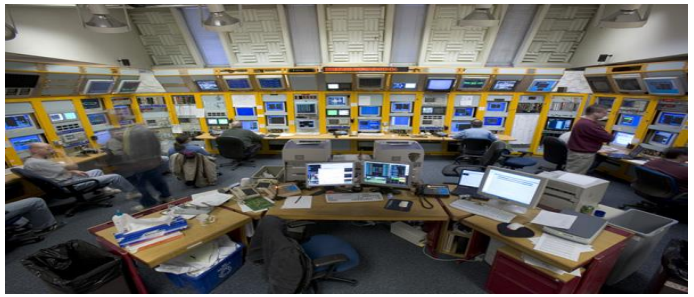


Cascading failures are becoming more likely with the ever-increasing dependence on information technology.

Grave consequences – financial and well being

Ever-increasing dependence on IT Infrastructure Resilience must catch up!

HSBC general bank ledgers
Credit: Y. C. Chan



SCADA services
http://www.trinitysystems.co.in/

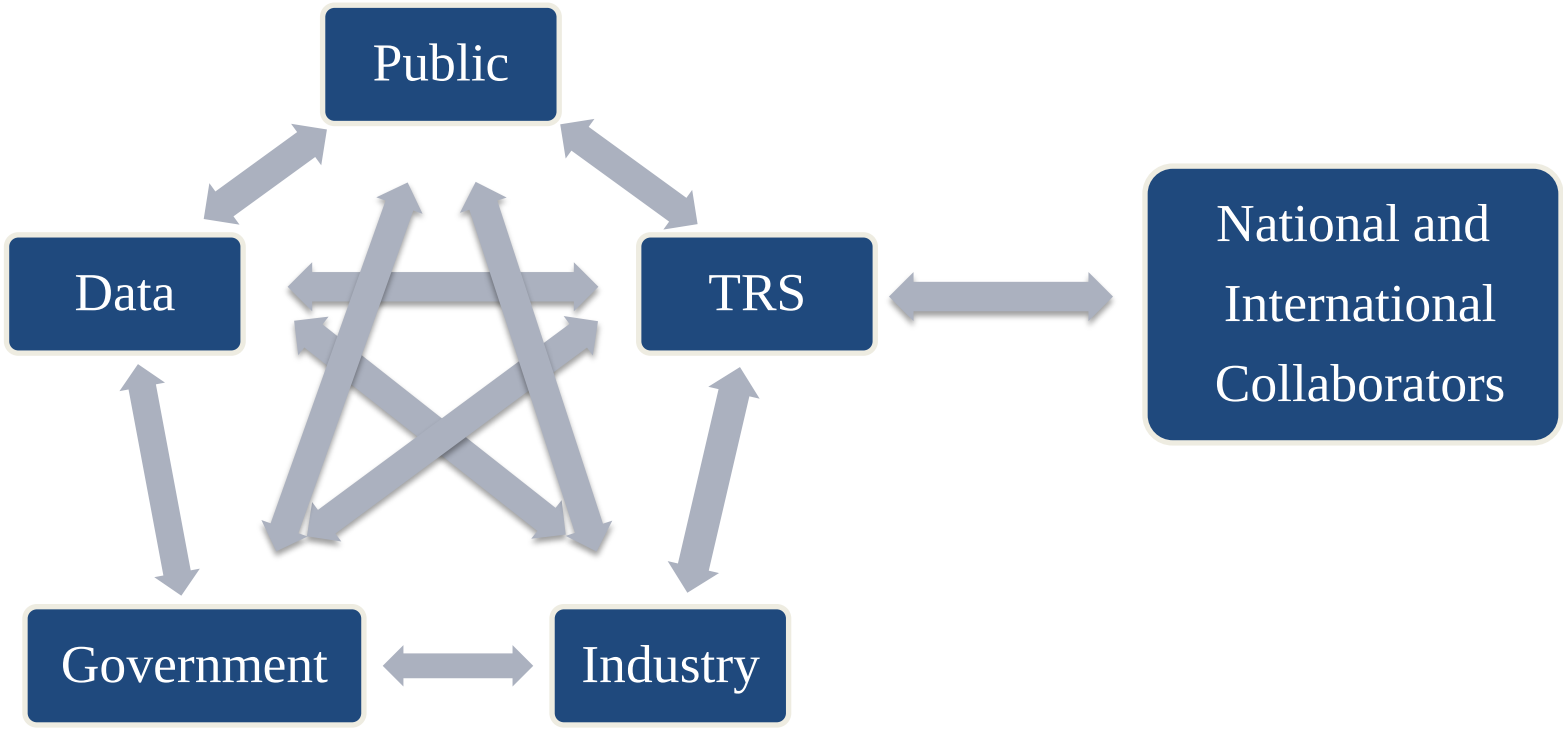
Examples: 2003 Blackouts

Italy 28 September 2003; US-Canada 14-16 August 2003; Affected around 100 million people; cost: $ billions; cascading failures: Internet and electricity infrastructures.

1. *Cowie, J.H., Ogielski A.T., Premore B.J., Smith, E.A. and Underwood T., Impact of the 2003 Blackouts on Internet Communications, Renesys Corporation. March 1, 2004.*
2. *S. V. Buldyrev, R. Parshani, P. Gerald, H. E. Stanley, and S. Havlin, "Catastrophic cascade of failures in interdependent networks", **Nature,** vol. 464, no. 7291, pp. 1025-1028, April 2010.*

Collaboration, education and communication

- TRS: HK engineers, mathematicians, scientists, social scientists and collaborators from HK, Mainland, neighboring areas and other countries.
- To achieve impact the TRS must also work with all stakeholders: public, government and industry.
- Accessible data (with some limitation) is very important.



Research Objectives

- Optimize a resilient infrastructure planning strategy (including adequate redundancy in resource allocation + flexible configuration) considering investment cost as well as the risk of infrastructure failure(s).

Such optimization will require the following:

1. Quantitatively define the cost of infrastructure failure(s) considering socio-economic factors.
2. Provide modelling, simulations and analyses (probabilistic and deterministic) of disasters and their effects on interdependent infrastructures.
3. Develop means for collection, organization, management, presentation, visualization of data on various infrastructure networks and potential disasters.

Expertise in Hong Kong

- Infrastructure networks (e.g., ICT, power, and transportation) (CityU, HKBU, HKU, CUHK, HKUST, PolyU)
- Geo-hazards such as earthquakes and landslides (HKUST, HKU, CityU, PolyU)
- Atmospheric science (CityU, HKU)
- Social sciences (HKU, CUHK, HKUST, CityU, PolyU)
- Mathematics (HKU, HKUST, CUHK, CityU, HKBU, PolyU)

Conclusions

- Advancements in infrastructure resilience research must catch up with the ever-increasing dependence on information technology and the concern of cascading failures in critical infrastructure.
- This is especially important for the highly urbanized Hong Kong society.