



Circle

Critical Infrastructures: Relations and Consequences for Life and Environment

An interactive touch table application for cascading effects analyses

Societies are becoming more and more dependent on different critical infrastructures in their daily life. Damages to one of these infrastructures or a combination of them through cascading effects can cause severe disruptions in urban areas. There are still many uncertainties on how cascading effects develop during and after a flood for instance. With the stakeholder tool Circle expert knowledge is combined to analyse and predict cascading effects between different critical infrastructure networks.

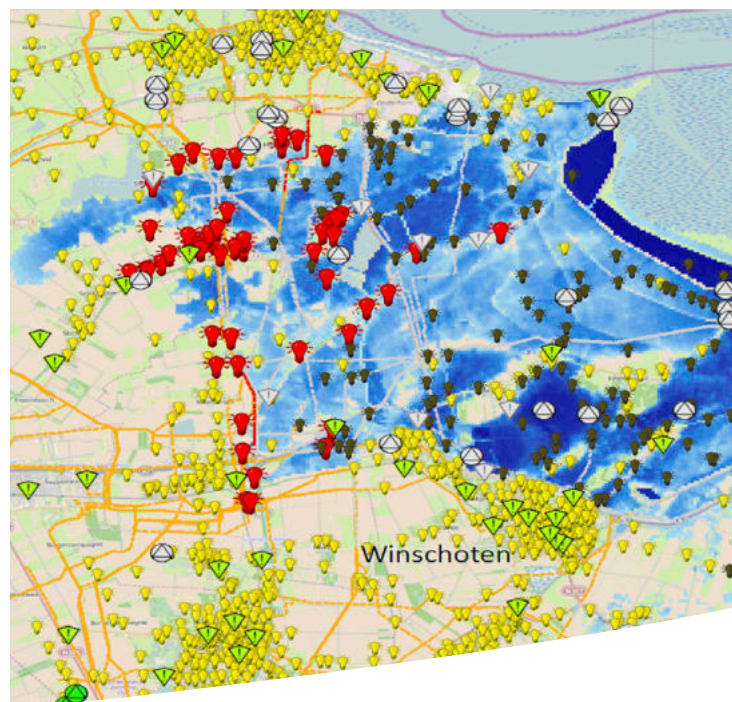
Case studies

Two case studies in the Netherlands on cascading effects of critical infrastructure based on open data have been carried out. Though the data alone was not sufficient to analyse and visualise these effects, interviews with network owners proved very valuable and gave insight in how the open data could be used at best.

It became clear that when data and knowledge was combined in a smart way, there is less need to access detailed data from the network owners themselves. The results of direct impacts from a flood and cascading effects were indicated as roughly the same or very likely by the network owners we talked to. Figure 1 shows the results of a possible electricity black-out during a certain flood scenario at a specific time step based on open data and network knowledge.

Because open data is widely available but knowledge is not, we created a stakeholder participation tool that gathers valuable knowledge on network behaviour and impact.

Figure 1: A possible electricity black-out during a flood based on open data.



Cascading Effects

Until now connections between Critical Infrastructure networks are hardly identified. Critical infrastructures are dealt with separately, even though different parties are aware of their interdependencies and possible cascading effects in case of floods or other natural hazards. Still it is not clear if cascading effects cause a major part of the total impact or if these effects are relatively small. Furthermore, data is mostly unavailable and dependencies are not automated, which makes it difficult to determine the effects on a certain location and hinders an adequate coordination and disaster management.

The reason why data (on for instance the energy networks) are not publicly available is that they are vulnerable for misuse. Network owners are often aware of the possibility of cascading effects and their connection with other networks or vulnerable objects, but struggle with the confidentiality of network data. For two case studies, Deltares performed an analysis on possible cascading effects after a flood with the use of open data and expert knowledge and verified the results with several network owners. The results were evaluated by network owners to be adequate and close to their simulations.

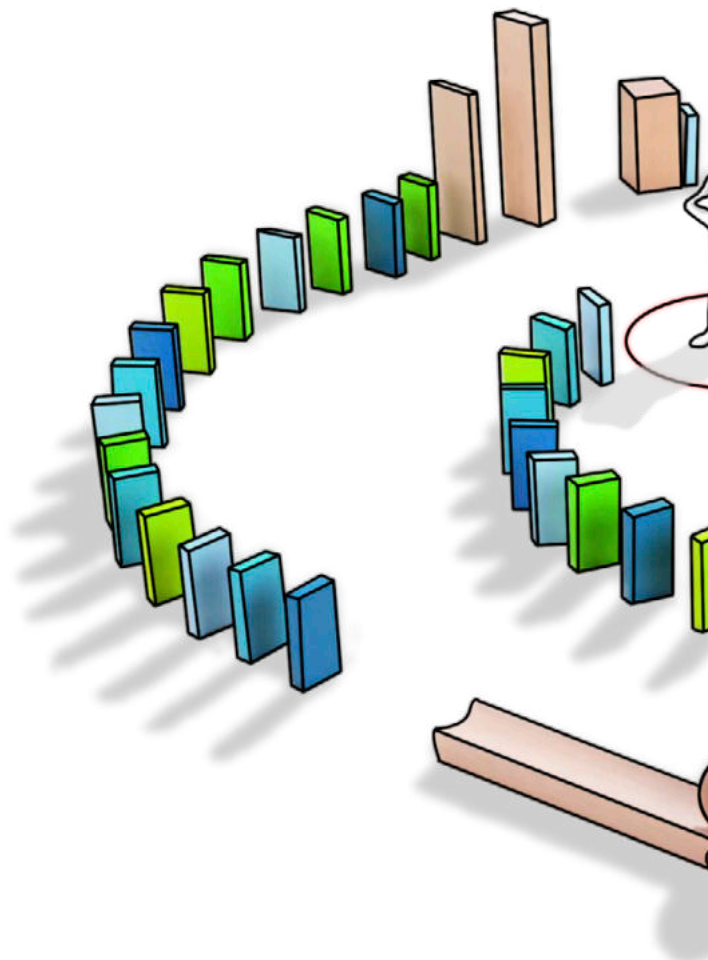


Figure 2 Threshold of a few decimeters above ground within substations

Circle

The two cases showed that not all data is needed to perform a cascading effect analysis and that network owners do not need to give all their data. On the other hand, there still is a need for knowledge on the operability of different networks.

For this purpose Circle is developed, a touch table application for workshops. Within workshops, different network owners, stakeholders and authorities or governments can find out and discuss cascading effects together.

During the discussion, dependencies between the networks or objects are drawn and the causal relationships between them are collected in a database.

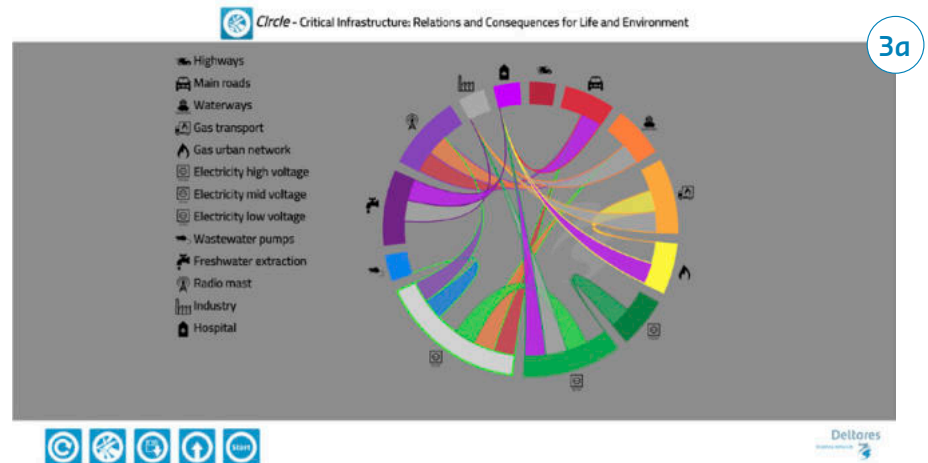
Examples of these causal relationships are:

When during a flood the water depth reaches 25cm, the electricity substations stop functioning (see also Figure 1).

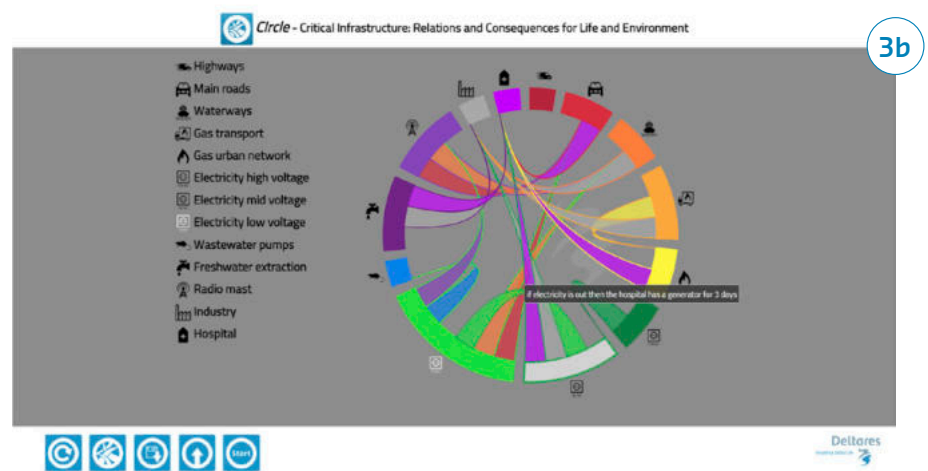
- When electricity falls out, a certain industry relies on temporary measures for 3 days.
- When electricity falls out, the C2000 emergency communication network will remain working for 8 hours. After that they will fail as well.



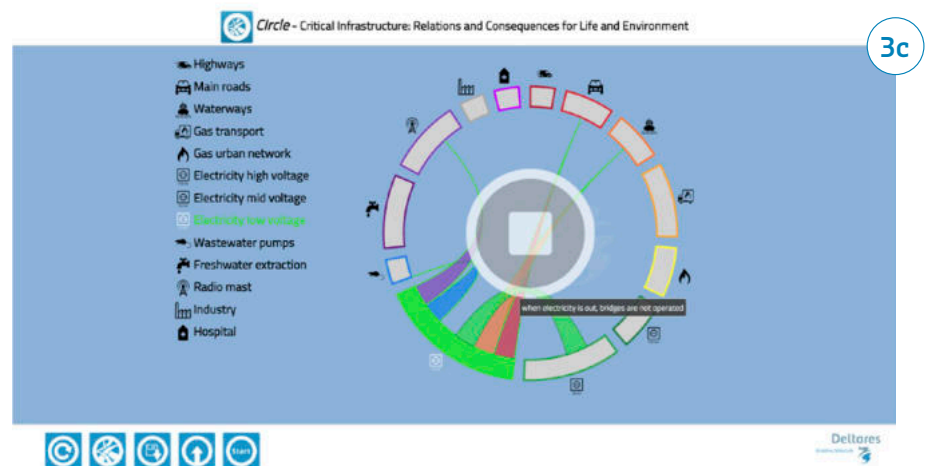
It was great to meet the different stakeholders and to learn who is depending on whose Critical Infrastructure.



3a



3b



3c

Figures 3a, b and c: Screenshots of the Circle tool in which expert knowledge and experience is entered for instance "when the electricity falls out, the hospital can use a generator for three days". The tool shows the results of the dependencies between networks and vulnerable objects after a Circle workshop with stakeholders.

Figures 3a and b show Circle while establishing and defining the connections. For each arrow causal relationships can be collected in the database of Circle. These causal relationships are very important for the performance of cascading analyses. Without these, time-dependent analyses and automated GIS analyses are not possible.

Figure 3c shows the end result where all discussed connections are projected at the same time. Every time such a multi-stakeholder workshop is done and the database of Circle fills up with causal relationships, the cascading effect analyses will improve.



Figure 4: Participants of a Circle workshop indicate some of the cascading effects.

Natural hazards

The workshops can be organised for different set-ups. It is not strictly necessary to have all the network owners or stakeholders around the table. Every set-up will be interesting for the attendees and valuable for Circle and cascading effects analyses as long as everybody voluntarily shares some of their knowledge. At the moment Circle is used for flood related cases and connected to state of the art flood and flood risk models like 3Di. Maps and animations can be used to show the results of cascading effect analyses obtained with open data. Participants of the workshops (Figure 4) can comment these existing analyses and indicate if the reality might be different. The causal relationships from the workshop are used to create a second cascading effects analysis as a final result. The differences between these two analyses

are valuable for new workshops and the insight in cascading effects.

Circle will not only be used to collect cascading effects caused by floods, but is applicable for any natural hazard. Some cascading effects might be universal and not typical for floods, which makes the gathered knowledge very useful.

Circle is a simple but effective tool for stakeholder participation in an increasing complex and inter-dependent society. It serves as a missing link in the insight in cascading effects caused by natural hazards and will be valuable for robustness and climate change adaptation research in urban areas.

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