VIKING

(Vital Infrastructure, NetworKs, INformation and Control System ManaGement)

SUMMARY REPORT

VIKING Cities Simulator (ViCiSi)

1 ViCiSi, the Virtual Cities Simulator

The cost and consequence assessments of the story boards are based on a virtual society. This society is a simplified but still functioning virtual society. It has static as well as dynamic properties. It has the vital features of a society. The society is named Viking Country. The virtual country is created with a software product developed within the VIKING project called ViCiSi, the Virtual Cities Simulator.

An extensive description of ViCiSi, the virtual society and the cost & consequences assessment can be found in the report "D.3.3 Consequence and cost analysis of SCADA systems vulnerabilities". In following a short summary is presented.

Overview of the virtual society

A society is heavily dependent of a resilient infrastructure. Among those infrastructures some are critical; for instance, electrical grid, the information networks and the financial services. They have a special position – the society can't operate without them. If the power disappears nearly all other society activities will halt immediately. For example, if the information networks or the financial services don't work it will cause a break down in most society activities after a shorter or longer while.

The virtual society is a simplified society, with only the vital features of a society. It has static as well as dynamic properties:

- Necessary infrastructure like blocks, apartments, streets, electricity grids etc.
- Companies, public and private service operations producing welfare
- People living in the city, having a comfortable life and consuming welfare.

The virtual society is a virtual dynamic society reflecting:

- Societal and business activities
- Critical infrastructure
- Individual objects

The virtual society relates:

- Power demand to an economic life; business activities to consumption of welfare

- All activities to the production and consumption of Gross Domestic Product (GDP)

The virtual society has Activity Profiles:

- Individual Power Demand Profiles for objects in the city
- Individual Business Activity Profiles for objects in the city

The virtual society has dynamics; the life in the city is managed by setting and incrementing a system time. The virtual society will be disturbed by simulation of outages in the power supply. The virtual society can:

- Measure the lost power consumption and the lost consumption of welfare
- Measure the economic activity in the society by measuring the production and consumption of welfare

The virtual society is created by ViCiSi, the Virtual Cities Simulator, which has been developed within the Viking-project. In the Viking-project the focus is on the electrical grid and the dependencies of a reliable power supply.

After ViCiSi has created the virtual society the society “lives” and:

- Has its own system time
- Responds to commands from the environment
- Sends information about its internal values, depending on the system time

Template countries

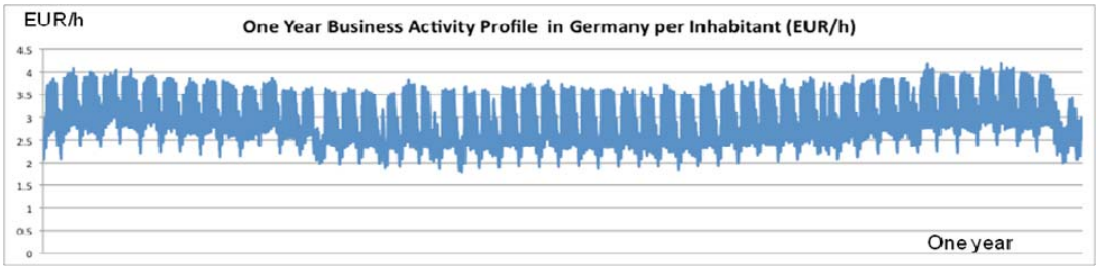
Viking Country is implemented from template files. There are templates for all EU countries. The template files are created by importing country demography and economic statistics from Eurostat and power statistics from the national Transmission System Operator. It is important to understand that we are not modeling real countries, for example Germany, but a virtual country with the same power consumption pattern and economical structure as Germany.

Power Load Profiles

In Viking Country all power consumers has there own individual Power Load Profile, i.e. the evolution of the created power demand during one year. To make the individual Power Load Profiles consistent the sum of the profiles equals the Power Load Profile from ENTSO-E, both at each moment in the time frame and summed for one year.

Business Activity Profiles

The dynamic features in the society are described by business processes and implemented as Business Activity Profiles to all business objects in the virtual society. The Business Activity Profiles defines a momentarily value for the economic activity for each society object over the year. If those activities are summed for one year for all objects the sum equals the Gross Domestic Product of the template country:

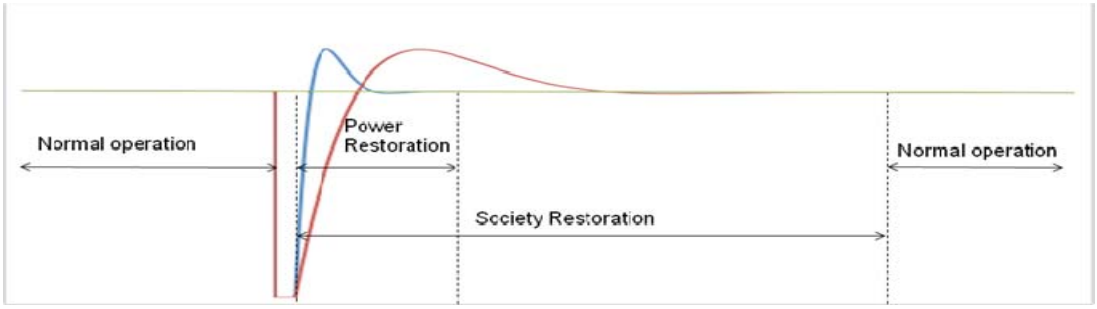


Business Activities Profile (Germany)

Outage and Restoration

The development of an outage in a society is very simple for the power as well as for the business activity. Everything gets black and more or less all production halts. And this continues as long as the outage lasts. No production or consumption of welfare is assumed to occur without electricity. In reality the development of an outage is a bit more complex but this is the simplification made in the virtual society in this report. But when the power comes back the restoration is modeled more complexly. The society gradually starts by consuming power and some of the undelivered energy will now be restored. For example a deep freezer will run intensively for a while and restore some of the undelivered energy. But a lamp will not restore any of the undelivered energy. It is not possible to recover lost light.

The virtual society created by ViCiSi has its own model of restoration, including open loop as well as closed loop properties. Thus it is possible to model long as well as short outages. This function is used to model the restoration of the power as well as the business, but with different time constants:



- ***Power Restoration*** is the stage where the demand for power is increasing after the grid has been energized. Some lost energy will also be recovered.
- ***Society Restoration*** is the stage where the economic activity in the society is increasing after the grid has been energized. Some lost economic values will also be recovered.
- Society Restoration is normally considerably slower than the Power Restoration

Power and Business Restoration

Assessment of cost and consequences

The assessment of cost and consequences in this report is comprised of one monetary dimension and one non-monetary dimension:

- an extensive *Impact Cost calculation*, based on the Gross Domestic Product and Business Activity Profiles,
- The *Macro and Micro perspective* of the consequences in a society, assessed by the *Impact Magnitude, Disturbance Length Order and Impact Incidence*.

The assessment of Impact Costs

The Impact Cost in a society occurring after an outage is assessed as the difference in the Gross Domestic Production (GDP) in a society with and without outage and is thus assessed as the lost GDP. The way Impact Costs are measured in the virtual society is by comparing the economic activity in a non disturbed society and the economic activity in a disturbed society. The cost is the difference between those measures. The cost is thus the value of the lost production.

Impact Magnitude is a new non-monetary dimension

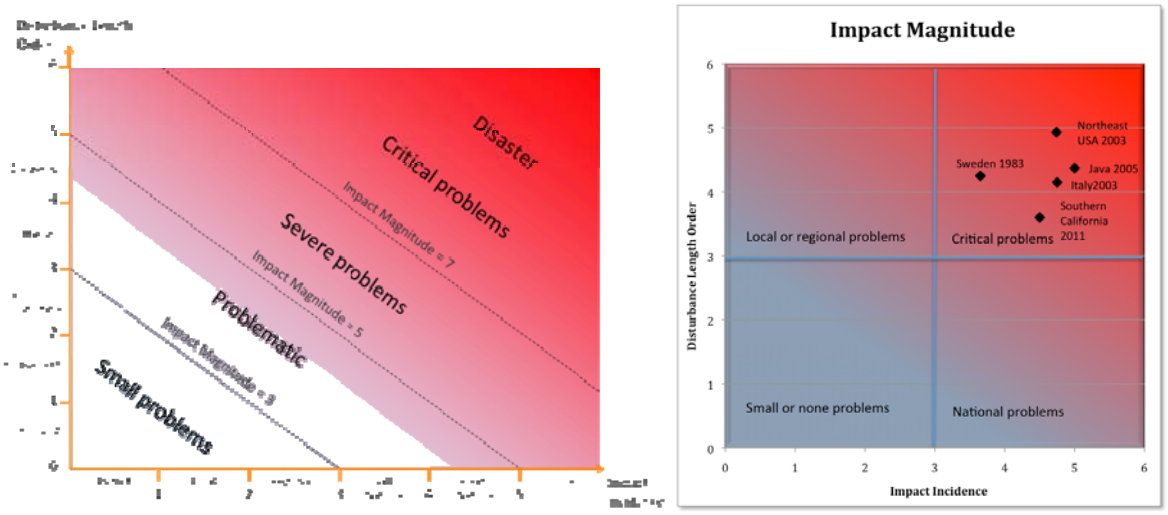
A new *non-monetary approach* to assess the consequences is defined in the Viking-project as a complement to the cost assessment. In this new approach the society is viewed and assessed from a micro perspective and a macro perspective. From the *micro perspective*, i.e. from the individual standpoint, the length of an outage is the most important dimension. In the micro perspective an outage means the loss of welfare, inconvenience, problems with transportation, no fuel at the gas station, problems with emergency calls etc. The micro dimension is covered by the so called *Disturbance Length Order*.

The number of affected people is not assessed in the micro perspective. From a societal standpoint - or the *macro perspective* - the consequences are dependent of the number of affected people. In the macro perspective societal risks are assessed, for example disease proliferation, riots and other crimes, antagonist attacks etc. The magnitude of those risks is related to both the number of affected persons and the length of the outage. The number of influenced people is covered by the *Impact Incidence*.

The over-all non-monetary dimension of the consequences is captured in the *Impact Magnitude* dimension, such as:

Impact Magnitude = Disturbance Length Order + Impact Incidence

From this the Impact Magnitude of historic well known outages can be assessed:



Impact Magnitude

The relationship between the Impact Magnitude and the consequences

The consequences from outages are thus dependent of both the length of the outage and the number of affected inhabitants. The Impact Magnitude and the consequences from a 1.000.000 inhabitant society can be summarized in the following table:

Impact Magnitude	Outage Length	Operation	Consequence
3	1 second or shorter (or shorter)	Process industry	The process might stop, with a long restoration time
		Computer system	The system might stop, information losses
		Air traffic control	Air security threatened
4.8	1 minute	Intensive care	surgical Lights stops, respirators and dialyze won't work, ventilators and dialysis won't work
5.8-6.0	10-15 minutes	Computers with battery backup	Stops but no information losses
6.0-6.3	15-30 minutes	Poultry breeding	Animals in big farms will die
6.3	30 minutes	Process industry	Ovens and pipes get clogged, restoration can last for a couple of days
6.9	2 hours	Big pig houses	Lack of ventilation can cause the animals die
		Water supply	Consumers in high-altitude areas are left without water
7.3	6 hours	Melting industry	Melts solidified in the pots (many weeks of downtime)
		Greenhouses	Damage by drought or freezing
7.5	8 hours	Water supply	Risk of contaminated water leaking into the pipes
		Heat supply	Problem particularly in hospitals and the elderly in their own homes
		Dairy cows	Risk of mastitis and sustained reduction in yield
7.6	10 hours	Telecommunications exchanges with battery backup	Disruption of telecommunications traffic
7.6-7.9	12-24 hours	Humans and animals	Lack of water and suitable food
		Food	Chilled and frozen foods are destroyed
		Retail	Retail distribution will have difficulty
		Commercial and residential	Freezing, risk of frost damage to water pipes
		Waste Water Treatment Plant	Raw sewage flows out through the overflow
> 7.9	Couple of days	Everyday life	Workplaces and service facilities must be kept closed

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