Simulation and Anticipation in Critical Situations Caused by Flooding

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Abstract
Globally flooding is one of the natural catastrophes that every year causes most victims and the greatest economical effects. In Sweden and other European countries death caused by flooding is relatively unusual, but the damages in tangible assets and the cost for the society are considerable. In case of flooding many authorities and organizations become involved and there is a problem to take in the whole situation and have a common picture when many incidents happen at the same time. There is also a lack of efficient tools showing critical buildings and constructions such as roads, railroads, water-purifying plant, etc, in combination with actual and forecasted water levels. In this paper we discuss anticipation of critical factors to be included in a model for visualization of situations caused by flooding.
Keywords: Anticipation, flooding, simulation, critical factors, Multi-Model systems method

1 Introduction

When lakes and watercourses are flooded the water-level is increased that much that, normally dry territories are put under water. Even areas that normally not are bounded by water can be flooded. Globally flooding is one of the natural catastrophes that every year causes most victims and the greatest economical effects. In Sweden and other European countries we are relatively spared from big flooding catastrophes and death caused by flooding is relatively unusual. Damages in tangible assets and the cost for the society are however considerable.

High water levels and the power of gushing water can cause great damage on settlements and infrastructure. Buildings are often water damaged both by direct flooding and by water rushing in through overloaded systems of water mains and outlets. Ground that is saturated with water combined with erosion can cause landslide damaging settlements, roads, railways and bridges. Destroyed and flooded roads lead to difficulties in pass ability and disturbance in communications. Flooded cables and bridge signal cabins can lead to disturbance in electricity supply and telecommunications. Damaged water supply and destroyed cables and pipes is a threat to the society and if purifying plants for outlet are hit, peoples health and the environment might be jeopardized.

As several authorities and organizations become involved in case of flooding, there is a problem to take in the whole situation and have a common picture when many incidents happen at the same time. Priorities are hard to make as there is a lack of efficient tools showing critical buildings and constructions such as roads, railroads, water-purifying plant, etc, in combination with actual and forecasted water levels. Furthermore, coordination between concerned authorities and organizations is not as effective as it could be.

2 The CRISSI Project

The aim of the whole project is to present a model for visualization of critical situations caused by flooding, and to develop a computerized system for simulation based on that model.

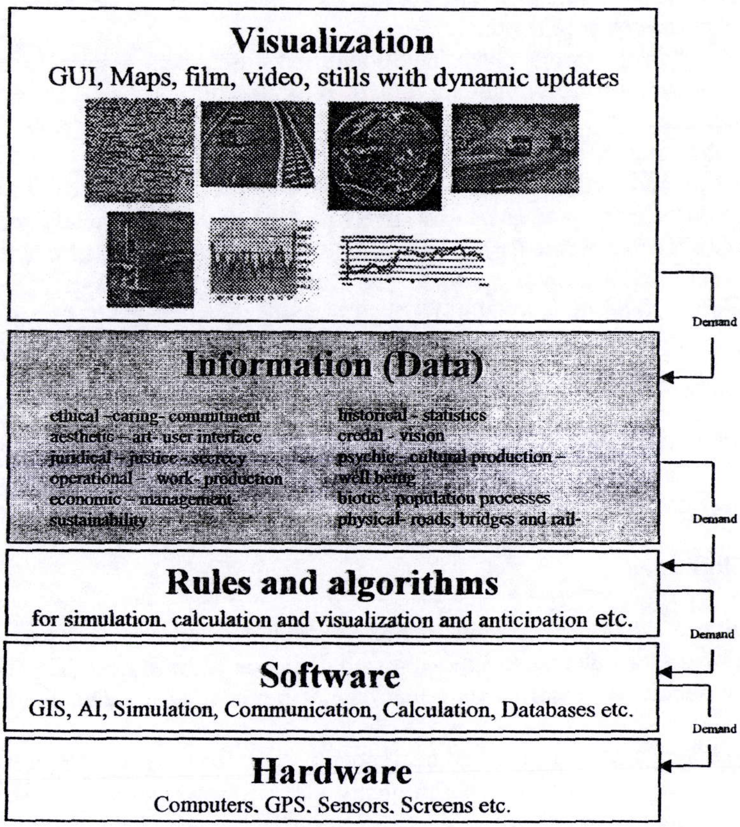

Figure 1: A model for the work with the CRISSI-project.

Questions at issue:

- Which authorities and organizations are affected of such critical situations?
- Which are the critical factors or variables that the system must be based on?
- How can visualization of a critical situation improve the understanding of the situation?
- Can visualization of dynamic processes contribute to the understanding?
- In what way can multi-media and GIS-systems contribute?
- Which calculation models (for example hydrological) are useful?
- How can anticipation contribute to the system?
- Which existing tools are useful for inclusion in the system?

In earlier work we have approached problems concerning decision support for spatial planning (Asproth et al, 1999; Asproth et al, 2002), spatial modeling and simulation (Asproth et al, 2004), water regulation (Asproth et al, 2001), and visualization of spatial decision situations (Asproth et al, 2002). That work can be seen as background or base for the project.

So far in the project, we have identified the critical factors to be included in a model for visualization of situations caused by flooding. We have used the Multi-Modal Systems Method, as developed by JDR de Raadt (2000), to be able to grasp the full width of human life and any human activity system. Interviews with representatives of authorities and organizations with experience of earlier flooding have been carried through. The interview questions have followed the Multi-Modal Systems Method in order to cover as many aspects as possible. Documentation of earlier flooding has also been examined. This work is to fill the "Information box" in figure 1 (grey-marked in the figure). (Asproth et. al. 2005)

In this paper we discuss anticipation of the critical factors to be included in the model for visualization of situations caused by flooding.

3 Critical Factors

The critical factors identified in the earlier studies are presented here in chapter 3.

3.1 Character

Ethical Modality: In our model, the ethical process consists of upbringing, education and influences from media, and demands commitment. This is something that must permeate the final system, and cannot be seen as a stand alone variable in the system.

Juridical Modality: The juridical modality concerns laws and regulations. In case of critical situations, secrecy is no problem today. Information that is classified as secret, such as crime and case of illness, can be entrusted between authorities.

Aesthetic Modality: Here, the user interface is important. A system for visualization and simulation of critical situations caused by flooding, needs information coming from many sources. This means that the information is varying both in type and quality. Presentation and visualization of this information will be important in the system.

3.2 Community

Economic Modality: Work requires resources and management to be viable, and this is the function of management, which belongs to the economic modality. The economic modality means allotment or distribution between consuming in the short run and long term use of the resources (for the future), i.e. a well- balanced use of common resources, and characterizes of sustainability.

Operational Modality: Work is something that belongs to the operational modality. The operational modality represents by different kinds of *production processes,* which can vary from one region to another. Examples are hydroelectric production, timber production, consumer goods production, and production within the tourist and recreation industry, and characterizes of a number of production systems.

Social Modality: Work and its management require a social structure. The social modality represents by the *public service production* and especially health care production, and characterizes of a number of public service systems.

3.3 Intellect

Epistemic Modality: The epistemic modality is the realm of understanding, and is provided by information. The education processes, the research and development processes, and the innovation processes here represent this modality, and it consists of educational systems, research and devel-opment systems, and innovation systems.

Informatory Modality: Information can be collected from different sensors as well as from historical data. In our model, information processes contains sensing, storing, retrieving, editing, and distribution of information. Media Processes and Soft Early Warning Processes are special cases of information processes. The modality consists of information and sensor system. The problem here is to set aside misunderstandings when actors from different branches communicate. It calls for a common glossary.

Historical Modality: Particularly in a system that handles critical situations caused by flooding, historical data are important. To be able to anticipate a critical situation, historical data and realistic models are of vital importance

3.4 Nature

Psychic Modality: The psychic modality is here represented by cultural production, i.e. all types of cultural processes for human mental well-being, and it consists of cultural production systems.

Biotic Modality: The biotic modality is here represented by population processes. These processes are functions of the obtained quality of life in the region, i.e. they represent the ultimate result indicators. Population represents both the number of persons living in the region and the physical health and age distribution of that population. Floods can lead to serious health problems, but also cause damage to the environment, people and animals in the long term. Examples are epidemics and contaminated water (water pollutions).

Physical Modality: Weather processes and vegetation processes represent renewable natural assets while resource utilization processes represent utilization of non- renewable natural assets, and the physical modality consists of water reservoirs, forest reservoirs, mountain resources, and energy reservoirs. Here it is necessary to have information about roads, bridges and rail-roads, and if there is any risk for undermining in this area. Information about industries and purifying plants, power stations and telecommunication offices are also required.

Kinetic Modality: Communication processes here represent the kinetic modality, such as transportation of persons, goods, and information, and it represents of communication systems. Particularly, information about goods that make a danger to man and environment, but also water regulation, is essential.

Spatial Modality: This modality is here represented by localisation processes, and its corresponding variables are spatial availability, density, and nearness. Examples are the spreading of the flood purely geographic, both historical and present. Geographic information about variables discussed in other modalities are: passable and blocked roads, washed away bridges and roads, blocked areas, heap of log jam in watercourses, critical or risky industries, purifying plants, risk for undermining of roads, bridges and rail-roads, and landslip disposed areas. Other information needed is owner of land and buildings, position of the police, home defence, military force, and other actors in the area. All these must be presented in GIS-system, completed with films and motion pictures, video and stills.

Numerical Modality: Examples are information about water levels, (present, calculated and altitude above sea level), together with stream rate, and rising (ex. per hour), resources (people, materials and equipment), and population register, precipitation (rainfall, snowfall).

4 Anticipatory Principles and the Multi-Modal System

When discussing de Raadts modalities, it is obvious that the three domains *character, community and intellect* can be associated with the administration of a corporation, a company or an organisation, and the fourth domain, *nature*, can be associated with the "product".

Spatial problem can be handled at any level in the organisation, *normative, strategic and operative level* (Schwaninger 1990), because the result of a decision making can give consequences in the long term or in a short time (see figure 2, Nature). Employing people, however, is a problem connected with the administration, but as for spatial problem, they can be handled at any level described above (see figure 2, Operational, Epistemic). (Asproth, Håkansson 2002).

Schwaninger (Espejo, Schwaninger 1993) has done the interesting observation that control variables at higher logical levels of management have a predictive power over variables at lower levels. However, in Multimodal Systems Thinking de Raadt (2000) has shown that the influences go in both directions. Higher modalities have an

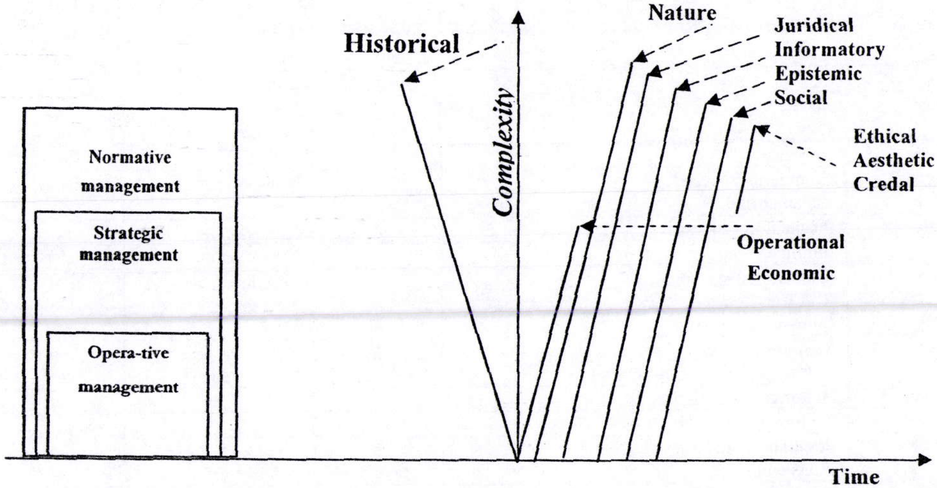

Figure 2: De Raadts Modalities in a time- and complexity perspective (Asproth, Håkansson 2002).

inspirational influence on lower ones and those, in their turn, have a restrictive effect on higher ones. Eriksson (2001) and Veronica de Raadt (2001) have shown practical applications of those insights.

When going from operative level to strategic- and normative level, the **complexity** increases. This fact also contributes to the stand that weak anticipation (Dubois 2000) is most useful at the operative level. With the same reasoning as for weak anticipation, strong anticipation could be useful at the normative or strategic level, where the **complexity** is high and the predicted future **time** is a long-term question. Concerning de Raadt's modalities, anticipation can be strongly efficient within the nature and community domains in the first place, as these two domains handle real and resolute problems with definite rules (Asproth, Håkansson, 2002).

5 Use of Critical Factors in the CRISSI-system

The critical factors that were identified in the earlier study, were further analyzed regarding the type of action that is possible to take to be able to simulate a future situation. Some of the factors can only be forecasted, while others also can be anticipated. Table 1 shows type of action for each factor and the time-perspective for the forecasting or the effect of anticipation. Finally, a decision was made if the factors were to be included in the CRISSI-system.

Table 1: Use of critical factors in the CRISSI-system
(A = able to Anticipate, F = able to Forecast)

Modality	Factor (process)	Type of action	Time perspective	Included in the system
Ethical		A	decades	no
Juridical	Secrecy	A	Now	Yes
	Laws and regulations	A	Months – years	no
Aesthetic	Interface			yes
Economic	Common resources	A	Now – years	partly
	sustainability	A	years	no
Operational	Production processes	A	Now - years	no
Social	Public service production	A	Now - years	partly
Epistemic	Educational systems	A	Months – years	No
	R & D systems	A	Years	No
	Innovation systems	A	years	no
Informatory	Media processes	A	Now – months	No
	Soft Early Warning processes	A	Now - years	yes
Historical	Historical information			yes
Psychic	Cultural production			no
Biotic	Population processes			No
	Physical health			no
Physical	Weather processes	F	Now – week	Yes
	vegetation processes	A	years	no
	water reservoirs,	A	Now – days	yes
	forest reservoirs,	A	decades	no
	earth deposits,			no
	energy reservoirs.	F	now - years	no
	Infrastructures	A	Now – days	yes
	industries	A	Now - days	yes
Kinetic	Communication processes	A	Now – days	yes
Spatial	(localisation processes)			
	spreading of the flood	F	now – week	Yes
	passable and blocked roads,	F	now – week	Yes
	washed away bridges and roads,	F	now – week	Yes
	blocked areas,	F	now – week	Yes
	heap of log jam in watercourses.	F	now – week	Yes
	critical or risky industries,	F	now – week	Yes
	purifying plants,	F	now – week	Yes
	risk for undermining of roads, bridges, rail-	F	now – week	Yes
	roads	F	now – week	Yes
	landslip disposed areas			Yes
	owner of land and buildings	A	now – hours	Yes
	position of the police	A	now – hours	Yes
	home defence	A	now – hours	Yes
	military force	A	now - hours	yes
	other actors in the area			
Numerical	water levels			Yes
	stream rate			Yes
	rising			Yes
	resources (people, materials, equipment)			Yes
	population register			Yes
	precipitation (rainfall, snowfall)			Yes
				Yes

6 Conclusion

In the presented part of the CRISSI-project we have identified the anticipative character of a number of critical factors for simulation and anticipation in critical situations caused by flooding. An important finding is that there is a time-perspective connected to anticipation. The effect of the anticipation appears after varying time-periods depending on the quality or characteristic of the factor. Furthermore, there is a need to analyse the interdependencies between the factors, as according to de Raadt (2000), higher modalities have an inspirational influence on lower ones and those, in their turn, have a restrictive effect on higher ones. This will be the next step in the project.

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