Inter-organizational Issues in ICT, GIS and GSD - Mapping Swedish Emergency Management at the Local and Regional Level

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ABSTRACT

Inter-organizational issues are very challenging in emergency management (EM). In this paper, aspects of information and communication technologies (ICT), geographical information systems (GIS) and geospatial data (GSD) in the Swedish EM system, an EM system involving a large number of EM organizations, are reported based on a case study. The issues concerned include separated ICT & GIS development between organizations and formation of technological coalitions, problems of identification and access of GSD, located through the large number organizations, as well as uncoordinated launching of web-based GIS service. Possible implications of this situation for command and control are discussed. Additionally, areas for further research are suggested.

Keywords

Emergency management, ICT, GIS, inter-organizational cooperation, geospatial data exchange, services.

INTRODUCTION

Many authors (for example Berrogi, 2001; Rubin, 1998; Johnson, 2002) point to the need of reassessing and redefining paradigms and theories of emergency management (EM) in terms of flexible and sophisticated command and control structures, broader operational frameworks, multi-disciplinary, multi-institutional, multi-jurisdictional, and multi-cultural cooperation with joint planning and sharing resources, as a necessary adaptation to the present development of society. From this perspective, structured and appropriate use of information and communication technologies (ICT) is an essential element with potential to improve resilience of EM organizations (Wybo and Lonka, 2002; Comfort, 1993; Comfort et al., 2001). Moreover, ICT will also become an indispensable part of modern emergency response operations (Mendonça et al., 2001). At the same time, even if ICT use in EM is just emerging, the changes ICT are bringing are already noticeable and affecting EM (Quarantelli, 1997; Rubin, 2000).

In this paper, the inter-organizational issues in terms of ICT, geographical information systems (GIS) and geospatial data (GSD) in Swedish EM are addressed. At present, a diversity of ICT systems integrating GIS with other technologies can be found among Swedish EM organizations. This concerns mobile decision-support systems, applications for command and control centers, tools for pre-disaster tasks, and various combinations of databases and desktop GIS. These solutions have focused on different phases of EM and achieved various levels of integration in day-to-day work. Further, these systems have often been linked together in numerous unique combinations. Implications of such development and its consequences have not, to the knowledge of the authors, sufficiently been investigated scientifically.

RESEARCH MOTIVATION

The potential use of geographic information (GI) for documentation, analysis and communication of complex events in society is stressed by many authors (Sivertun, 1991; Bernhardsen, 1999; Laurini and Thompson, 1996; Longley et al., 1999). GI, in the form of maps, constitute not only one but several important modalities for providing information and sharing a situation at the local as well as regional, national and international level (Sivertun, 2001). Geographical and situation awareness through GI plays a central role in decision-making processes, making GI and GIS integral parts of EM (Snell and Simpson, 2003; Jungert et al., 2004). These decision-making processes often involve GI concerning specific emergency events, such as accidents, emergencies and disasters, collected via different techniques of rapid mapping, such as observations, automatic surveillance systems and sensor networks, in real-time or "near" real-time. In planning and analytical decision-making, so-called "context" GI is also involved in addition to the "event specific" GI (after Granlund, 1997). The need of "event specific" and "context" GI is expected to be different and unique to each event. Additionally, taking into account the aspects of different jurisdictions, individual missions and priorities of particular EM organizations, their GI needs are likely to differ too. The volume of both types of GI, in the form of geospatial data (GSD), will also be rising with regard to the complexity of present events as well as the increasing use of

automatic surveillance systems and sensor networks. Furthermore, the number and variety of the sources of GSD will therefore most likely be growing too.

This situation has implications considering the nature of Swedish EM, where responsibilities and decision-making are delegated to the regional level and in particular the local level. Thus, the concerned decision-makers and commanders are located as personnel in a large number of EM organizations, including 290 municipal administrations and 250 fire and rescue services, 21 county administrations, 21 county health boards and 21 police authorities and several national government bureaus (NGB). Consequently, a significant problem becomes the delivery of the appropriate information, in this case GI, to the proper party at the appropriate place and time, and in a useful form (Quarantelli, 1997; Radke et al., 2002). With continuing computerization and information explosion, decision-making will even be more challenged due to accelerated loss of "event specific" GI, lack of "context" GI, increased risk of information overload, and greater and quicker diffusion of incorrect information (after McEntire, 2002; Quarantelli, 1997). Furthermore, the ability and capacity to access GI in the form of GSD is not only influenced by skills of individual decision-makers, but also capacities within the whole EM to access these GSD and how well the GIS and GSD sources are coordinated with these capacities (after Artman, 1999). To address these problems today's limited coordination of GSD sources and often non-systematic use of ICT and GIS at the inter-organizational level (Gant, 1996) require to be replaced by a high degree of organization and preparation to support information needs and flow (Iakovou and Douligeris, 2001; Johnson, 2002; Kevany, 2003).

However, this is not often without problems. Inter-organizational relationships are seen as a major source of problems particularly in large emergencies and disasters (Stallings, 2002), since the organizations are inherently not equal as some of them are better organized and more powerful (Burkle and Hayden, 2001). The risk of conflict and competition between organizations is additionally increased by asymmetric distribution of ICT & GIS capabilities and resources (Quarantelli, 1997), inconsistent procedures (Comfort, 1990), blurred responsibilities (Iakovou and Douligeris, 2001), fear of losing control and power structures (Nedovic-Budic and Pinto, 1999) or becoming dependent on other organizations (Mulford, 1984). Furthermore, differences in awareness and handling skills (Nedovic-Budic and Pinto, 1999; Zerger and Smith, 2003) together with lack of knowledge, preparation and skills in collaboration (Iakovou and Douligeris, 2001; Granot, 1997; Kevany, 2003; McEntire, 2002) represent further obstacles for sharing and facilitating ICT, GIS and GSD at the inter-organizational level.

METHOD

To investigate issues related to inter-organizational issues of ICT, GIS and GSD in-depth within their real-life institutional and social context, an embedded case study method was chosen. The selection among the Swedish local and regional EM organizations was driven by searching information-rich units of analysis within a selected region – two neighboring counties. To select and document variations that have emerged in inter-organizational cooperation a combination of purposeful sampling, in particular a combination of critical case, criterion, and maximum variation sampling, was applied (Patton, 1990). In total, thirteen organizations with EM tasks were selected – three fire and rescue services (FRS), five municipal administrations, two county administrations, two county health boards and one county police authority. A standardized open-ended interview was chosen as the main data collection technique. Consequently, nineteen telephone and face-to-face interviews were made with representatives – ICT, GIS and GSD infrastructure responsible – from the selected EM organizations. In the interviews, areas of present ICT, GIS and GSD management and related future plans, inter-organizational cooperation and its forms, and GSD collection and exchange were addressed. The interviews were additionally completed with free unsystematic observations. These observations were carried out in an unobtrusive and in-house discussion style.

INTER-ORGANIZATIONAL COOPERATION

In this study, a variety of cooperation forms concerning ICT & GIS and reasons for such cooperation was found. Organizations type and relations between the organizations were the most important factors in selecting organizations to cooperate with. The motivation to cooperate with other organizations was further influenced by available competence, resources, and support, and possibilities for joint technical development. Regional organizations identified their sister organizations as the closest partners to cooperate with. Similarities in organizational structures and consequently facing same types of problems were mentioned as essential. The cooperation was mentioned as official containing regular working groups, seminars, meetings, etc.

Cooperation among the local EM organizations was not found very uniform due to the significant differences in size and available resources between these organizations. This was also reflected in the broader range of cooperation forms. Considering municipal administrations, similar organizational structures, in particular size of the administration, and facing same types of problems were also the main motivation for cooperation between these organizations. Further, the type of ICT & GIS solutions and their level of maturity were other important factors. This type of cooperation, recorded among the larger municipal administrations, was on bases of individual organizations, included small number of organizations and changed over time. A municipal administration may also have one or more partners for ICT issues and

other partners for GIS as GIS are often managed separately at Swedish municipal administrations. The cooperating partners were often selected independently of geographical location, being spread through entire Sweden. Such cooperation can be seen as technological partnerships or coalitions. Smaller municipal administrations mentioned their interest to join these partnerships with the larger municipalities for their resources and competence, however, we did not observe any such partnership to be set up. Besides these technological partnerships, the cooperation can be mostly described as "boundary spanning " (Mulford, 1984), i.e., various informal and unofficial discussions, consultations, meetings and visits based on personal contacts. Additionally, some organizations also cooperate in terms of occasional joint acquisition of ICT, GIS and also GSD on ad-hoc basis. A special case of cooperation, we recorded, was providing GIS and GSD management services by one municipal administration to another. There may also be cases when a municipal administration does not cooperate with others at all as we observed.

Compared to municipal administrations FRS as another type of local EM organizations do not have the same amount of freedom in selecting partners. This is due to their tight connection to their municipal administrations. This corresponds with our finding that the FRS identified the municipal administrations as their most important and closest partner to cooperate with for their resources, competence and available support. We have not found any official cooperation between pairs of FRS or any other EM organizations. Even if two or more FRS agreed on cooperation and sharing resources, ICT and GIS was not included in this cooperation. Consequently only informal and unofficial "boundary spanning" concerning ICT and GIS was found. Furthermore, without relation to organization type, i.e. regional-regional or local-local cooperation, some organizations also mentioned participation in regional GIS forums. These forums often involve personnel ("boundary spanners") from a broad range of organizations, such as municipal and county administrations, industry and central government organizations. The cooperation is however on bases of exchange of ideas, experience, etc. and to improve communication with occasional projects within these forums.

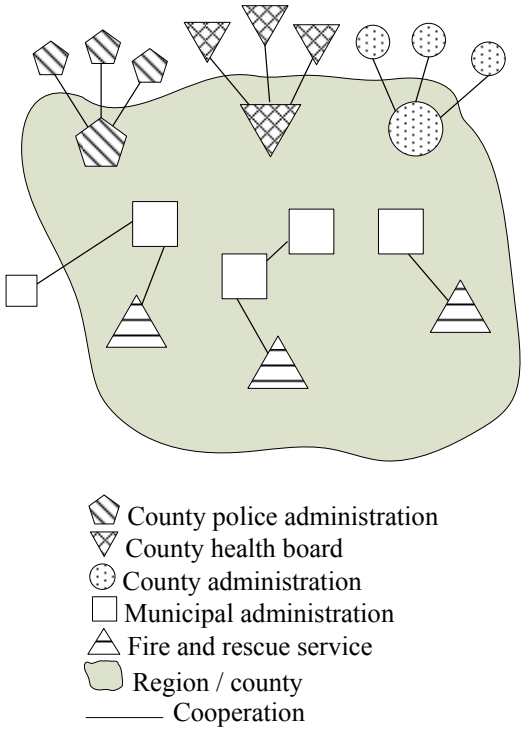

Figure 1. An overview of official cooperation among the local and regional EM organizations

From the emergency response perspective, location or distance between cooperating partners is influencing the selection of partners. Regional organizations, such as county police administrations and county health boards (responsible for providing emergency medical services), mentioned more intensive cooperation with their neighbours compared to other sister organizations. On the other hand, such cooperation concerning ICT and GIS was not recorded among the FRS. Some of the FRS pointed out their willingness to cooperate with other FRS and others, however, without success. In figure 1, an obvious segregation between different types of EM organizations can be observed. Further, separation between regional and local organizations can also be seen.

GSD INFRASTRUCTURE

Considering the present GSD infrastructure, base data, such as administrative boundaries, land use and infrastructure, are in place in most of the studied EM organizations. EM thematic GSD are however just in their beginning. Large amounts of EM related data are still kept in non-geospatial formats. Furthermore, taking into account the existing EM thematic and other GSD, these reside particularly at the local level. The GSD intensively distributed at the local level might be pointing to a different pattern in the topology of the EM thematic and other GSD sources compared to other data infrastructure, such as various centralized registers and databases managed more and more often at national and regional level. As a result, GSD sources differ greatly in number and variety compared to other digital data sources.

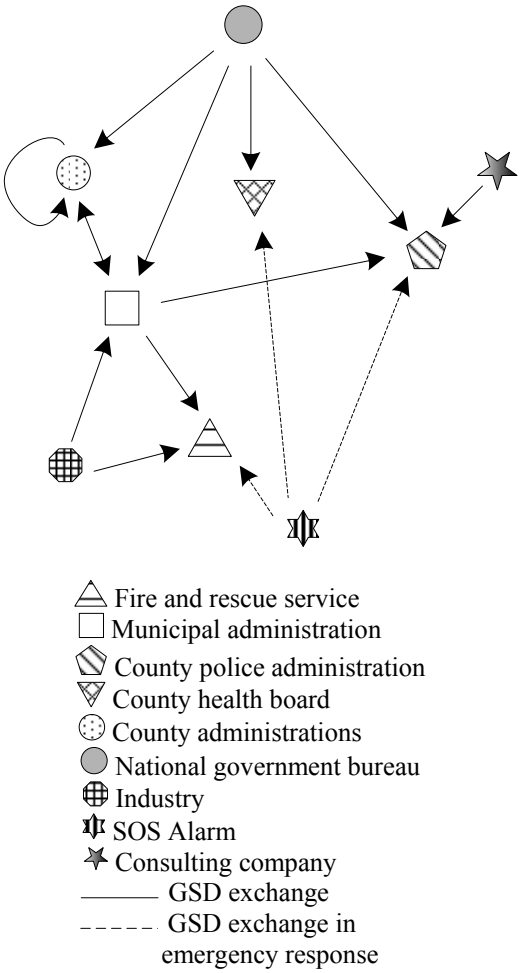

Figure 2. A scheme of main GSD sources identified by the studied EM organizations

In almost all cases own organization was identified as the main and sometimes the only single source of EM thematic GSD. The stress on collection of the EM thematic GSD by own organizations was more stressed by the local organizations compared to the regional organizations. The studied EM organizations also pointed out allocation and access of particularly EM thematic GSD outside their own organizations as one of the most problematic issues. Furthermore, many organizations often mentioned very limited official GSD exchange, and sometimes even of any kind, with other EM organizations. In figure 2, a scheme of main GSD sources identified by the studied organizations is presented. An apparent top-down flow from the national to local level can be observed. This GSD flow also concerns almost only base GSD. This corresponds with our finding as the organizations acquire data only for their own jurisdiction. Apart from the county administrations we did not record any GSD exchange between two different jurisdictions. With regard to emergency response, the only GSD exchange recorded between the emergency response organizations was communication with SOS Alarm (a provider of 112 services) concerning position and status of emergency events and responding resources.

Emergency response organizations mentioned their potential interest to have access to GSD in neighborhood jurisdictions in advance, as it would make it easier during larger events, such as emergencies and disasters. Nevertheless, they could not acquire these because of difficulties in identifying and accessing these GSD. During the interviews three

organizations mentioned their interventions towards their own organization in order to identify this type of GSD. These pointed out that practically no GSD of this type have been identified. These results are in contrast to the comments obtained from other EM organizations describing these GSD as potentially essential for their decisions. This is partially affected by the fact that utilization of GIS may change the structure of the information sets. It also points to low information awareness and underdeveloped capabilities to allocate and access GSD on neither push nor pull bases. Moreover, the EM organizations may stay away from using relevant information, considering GSD as extra challenging, if the access to the information is too difficult due to administrative and legislative obstacles, or the economical demands are too high, as documented by Hessman and Lissborg (1999) in their study of nineteen Swedish EM organizations. Consequently, these unavailable and missing EM thematic and other GSD lead into GIS, which are unable to support organizational tasks as initially intended by some of the studied EM organizations. One EM organization even highlighted that limited access to GSD from other organizations makes utilization of GIS in its work very limited and hardly meaningful.

Efforts to cooperate in order to improve access to GSD were recorded during the study. This was realized within the already mentioned regional GIS forums. Interestingly, none of the emergency response organizations was participating in these regional GIS forums. From the organizations taking part in the GIS forums, these particularly highlighted the possibility to build contacts for easier GSD access. As we observed, these contacts were often used to access and exchange GSD however this was performed on informal bases. The actual structure and volume of this informal GSD exchange was difficult to uncover and is in most part unknown. As our experience shows, these GSD exchanged on informal bases are normally delivered in industry recognized formats. On the other hand, GSD were often not only missing written agreements, regulating the exchange and use, but also either documentation carrying information about the data, such as author, scale, validity, quality, data description, etc. were missing. Even of the risk of unknown quality and thus additional uncertainty of the informally exchanged and fused GSD, we did not register any particular concerns regarding these issues.

The studied EM organizations pointed out their efforts to integrate all the GSD at the intra-organizational level. With regard to the observed problems at the inter-organizational level, we did not document any efforts to build regional GSD depositories or to share GSD from different types of organizations and jurisdictions. Thus, there seems to be obvious qualitative as well as quantitative differences in the approach to GSD access and exchange and its preparation within own organization, alternatively one shared jurisdiction, and between two different jurisdictions. In respect to that, one organization identified the present GSD exchange between the different EM organizations as a problem, particularly in time of emergency events affecting several jurisdictions.

SERVICE APPROACH – WEB-BASED GIS

In order to improve access to the GSD many of the studied organizations with non-emergency response tasks mentioned their use or intentions to use web-based GIS services as means for other EM organizations as well as for others to access their data online. However, from the already launched web-based GIS services these were only providing mostly elementary functions for visualizing, browsing and simple query of pre-generated graphic “map snapshots”, and real-time maps and images connected to conventional databases. In addition, such strong focus on the Internet and WWW raises concerns with regard to the risk of losing control over the selection of the information sources, their reliability, verification, etc. (Bucher, 2002). With increasing number of web-based GIS services, additional sources of GSD potentially increase the risk of conflicting sources and the probability of greater and quicker diffusion of incorrect information (Quarantelli, 1997). To demonstrate this problem we searched for online web-based GIS services for one middle size town in the study area. Within matter of minutes we found more than six services, provided by the NGB, regional and local administrations and business organizations. These services were mostly lacking any documentation of the GSD presented. Furthermore, the presented GSD were containing different information over the same geographical area. Such situation may as a result lead to EM organizations acting on disparate GSD from various sources while taking actions to control a shared situation or the same emergency event.

Additionally, web-based GIS services in their present form do not support the EM organizations in solving the problem of who needs to access who’s GSD nor what services are available and where these can be accessed. In addition, even if there are efforts in GSD standardization and creating open-GIS, the still limited technical interoperability between the web-based GIS platforms and services (ETeMII, 2001; Bernard et al., 2003), especially in EM, makes integration of GSD administrated using various vendor platforms into a single view presentation of a coherent data set challenging. From this perspective, improved technical facilities, considered in this case as the Internet and web-based GIS services, to access GSD from a single source do not have to automatically lead to better utilization of GSD among the EM organizations.

It is unclear if the studied organizations would provide any other forms of accessing their GSD online, but we have not recorded any explicit plans to do so. One organization emphasized its willingness to eventually provide direct online access to their internal GSD infrastructure for other EM organizations, but it was not possible due to IT security concerns. Considering other potential GIS services, services offering access and fusion of distributed remote GSD in real-time or near real-time using semi-automatic or automatic systems are partly developed, however there is no such

service provided for the concerned Swedish GSD. In addition, ad-hoc chaining of the services based on the situation needs is accomplished only at the experimental level (Bernard et al., 2003). In addition to the technical issues, services providing "just-in-time" and "point-of-action" mapping are considered as difficult to establish due to the different demands on GSD with regard to a level of detail, quality and point in time (DITF, 1997) by the particular EM organizations.

IMPLICATIONS FOR COMMAND AND CONTROL

With continuous networking, outsourcing and globalization more and new multiple sources of GSD are and will be available, as already documented during this study. Such development has implications for EM organizations using these GSD sources. As the command and control (C2) structures may be "regulated" by conventions, distance, geography, etc., the GSD sources are not limited by any physical borders, making these borders in principle meaningless (Alberts, 2002). Furthermore, the topology of the sources may become non-uniform and inconsistent, or even unknown, since the GSD sources may be independent and uncoordinated (DITF, 1997). This may have significant effects on C2 since the navigation among the sources may become difficult (Alberts, 2002). Furthermore, as the tactical and strategic preferences in C2 are recognized and their negative effects mitigated, these are however in the sense of selecting GSD sources "unregulated" and relatively unknown. As a result the GSD flow may have unpredictable architecture separated from the chain of command (after Levchuk et al, 2003).

Further, the present management of ICT, GIS and GSD infrastructure by the studied organizations follows hierarchical and quasi-hierarchical arrangements of C2 in the Swedish EM. This was also reflected in the inter-organizational cooperation among the organizations. This relatively low pre-emergency inter-organizational cooperation between different types of EM organizations and jurisdictions is likely to make it more difficult to cooperate for the organizations during large events (after Granot, 1997) when there is a need to shift from routine divisional C2 structures to situation driven functional C2 structures. From this perspective, deployment of ICT and GIS and utilization of available GSD in emergency response to large events is considered as potentially challenging, random and unpredictable.

CONCLUSIONS

Inter-organizational issues in EM are more challenging compared to other sectors due to its additional complexity, uncertainty, number of organizations involved as well as the space and time segment (Wybo and Lonka, 2002). In EM systems with responsibilities and decision-making distributed among a large number of particularly local organizations, such as the Swedish EM, inter-organizational issues of ICT, GIS and GSD are even more demanding. In our study, the EM organizations found it difficult to have some form of cooperation with others than sister organizations in terms of ICT, GIS and GSD. In general, the differences in resources, type of addressed problems, priorities, individual missions and data needs, etc. were the commonly named obstacles for cooperation by the organizations. The enduring research question is how to motivate the EM organizations to inter-organizational cooperation in terms of ICT & GIS infrastructure and GSD exchange since these are having problems to identify any threat-specific or strategy-specific issues encouraging such cooperation. The question could also be rephrased as how to manage and distribute GI to make it available throughout the EM community if the EM organizations often have difficulties to systematically coordinate their ICT, GIS and GSD infrastructure (after Jenvald et al, 2001).

In a broader perspective, with the intentions to shift from traditional organizational structures towards more network centric orientated frameworks, addressing of inter-organizational issues, particularly access to external GSD, will be even more essential as the capacity to access and to communicate remote (shared) GSD will be an important parameter for C2 structures. Inter-organizational cooperation and coordination however will not be easier as the service concepts accompanying the network centric frameworks are expected to most likely involve more and new organizations, such as various data custodians, value-add processing vendors, suppliers and service providers, as well as increase dependency on these external organizations than today (Persson, 2004).

Thus, further research on inter-organizational issues concerning ICT, GIS and GSD is necessary. In particular, effects of separated development of ICT and GIS on capabilities to perform joint operations by different organizations require further study. Changes and expansion of GSD sources in terms of globalisation, outsourcing and networking are another research topic with regard to implications of this development for C2 structure and their capacity to execute C2 work. Additionally, network centric frameworks and service concepts were so far studied at the operational level within homogeny military organizations. Thus, effects of network centric frameworks and service concepts on EM in aspect of strategic, tactical and normative level of command from the perspective multi-organizational coalitions need also further research.

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