
Network Enabled Decision Support for Civil Emergency Management

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ABSTRACT. Civil emergency management is discussed when more than one aid organisation is involved in solving an emergency problem. This paper analyses interagency cooperation, decision-making and leadership in the planning stages as well as during emergencies and disasters. Specific deficiencies about information exchange and interagency staff work are identified. The authors describe shared or parallel information processing and network enabled procedures between all involved emergency management organisations for supporting decisions made under time constraints, and point out the need for open source software strategies to maximise use, also involving small, voluntary NGOs. Finally, further research and development is called upon towards realising the aforementioned concepts for decision-making support.

RÉSUMÉ. La coordination des services civils d'intervention d'urgence entre en jeu quand plusieurs organisations doivent collaborer pour résoudre une situation grave. Cet article explore la coopération interorganisation, la prise de décision et la direction dans la phase de planification aussi bien que pendant le déroulement des désastres. L'article décrit l'analyse de données en parallèle par plusieurs équipes et des procédures dites « en réseau » qui peuvent être utilisées lors de la prise de décision quand la contrainte temporelle est très importante. Finalement, les auteurs suggèrent que des recherches plus approfondies soient entreprises pour mettre en pratique les concepts développés dans l'article en termes de SIAD.

KEYWORDS: Civil Emergency Management, Aid Organisation, Interagency Cooperation, Disaster, Information Exchange, Parallel Information Processing, Improvisation, Group Decision.

MOTS-CLÉS : services civils d'intervention, désastre, contrainte temporelle, logiciel libre, décision de groupe.

1. Civil emergency scenarios, emergency planning and management

1.1. Civil emergency scenarios: some definitions, an overview of current research and our working agenda

According to UN ISDR (2002) a disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses that exceed the capability of the affected community or society to cope using its own resources. Disaster operation is considered as a set of activities performed before, during and after a disaster with the goal of preventing loss of human life, reducing its impact on the economy and returning to a state of normalcy.

Altay *et al.* (in press) discuss disaster classification within a continuum, using emergency stages as categories from everyday emergencies to major emergencies, disasters and catastrophes. Emergency escalation is described as a transition process at the discretion of an appropriate governmental authority which uses declarative legal means, thereby moving from normal status to emergency stages with the resources of a single emergency organisation up to several emergency organisations, and from standard procedures up to non-standard procedures.

OECD (2003) stated that effective emergency management and response depends not only on actions immediately prior to, during and in the aftermath of a disaster but also - importantly - on preexisting plans, structures and arrangements for bringing together the efforts of government, voluntary and private agencies in a comprehensive and co-ordinated way.

We consider Civil Emergency Scenarios as situations in which normal life conditions for citizens are suspended, and extraordinary life conditions arise from an emergency which threatens personnel and material goods. Civil Emergency Alerts depend on the assessment of the situation in general, and more specifically on the assessment of the threat to personnel and material goods given in a defined time and space. Normally and in most cases Civil Emergency Alerts are dealt with by aid from Governmental Authorities' or Non-Governmental Organisations (NGOs) or both.

We suggest speaking about an emergency whenever more than one Organisation is needed and involved in solving an emergency problem. In such cases emergency procedures are defined and a Lead Organisation is assigned. This would enable an international comparison of statistics on how many emergencies arise per time interval per nation, whereas at large it is very difficult to count the total number of cases of all small emergency problems. Whenever a lower emergency stage cannot be solved at that level, emergency escalation needs to be declared.

Altay *et al.* (in press) summarize the publications in all fields of disaster and emergency and argue for Operations Research (OR) activities, including management science, management engineering and management consulting. Altay *et al.* (in press) analyse disaster and emergency research publications, and suggest methods of Modelling and Simulation (MS), as the topic - compared to more popular research topics

such as supply chain management - seems to lack research interest. From recent experience with the recent tsunami disaster and the World Trade Center attack, future OR research directions are suggested.

Comprehensive emergency management tries to generalise policies and plans for all kinds of emergencies, with structures and procedures close to normal daily routines. Different response needs are then stated for different incidents with equal physical evidence, e.g. given the possibly identical physical results of a bus accident compared to a terrorist attack on that bus. Thus, response to disasters requires research and decision-making support not for prepared emergency plans, but also for improvisation methods and technologies (Altay *et al.*, in press). These include:

- Multi-agency research, e.g. ambiguity of authority, political and ethical implications.
- Methods research, e.g. fuzzy systems, decision-making dynamics and uncertainty simulation.
- Technology research, e.g. real-time sensing, positioning and resource allocation.
- *Disaster Operations Management* research with focus on recovery stages, e.g. damage assessment, debris removal, clean-up, financial aid, aid distribution tracking, verification and controlling.
- Business continuity, e.g. recovery of computer networks and data as well as post-disaster logistical problems, failure rates and criteria for helping business survive.
- Critical infrastructure design, e.g. survivability of robust easy-to-rebuild network designs, structure-based and human-based disruption management models.
- Management engineering, e.g. the difference between disaster and everyday emergencies.

The US National Research Council, Committee on Science and Technology for Countering Terrorism, identified in 2002 "systems analysis, modeling and simulation" as the first research challenge. This is required for threat assessment, vulnerabilities and interdependencies identification, threat detection, response planning, first responders training, response coordination and decision-making response to terrorist attacks ((Jain *et al.*, 2003):

Emergency response needs an effort to create integrated distributed simulation models. The main challenges to be overcome are the interoperability between emergency response MS (modelling and simulation) applications, the cost of transferring data, and the simulation development process. The goal is to have the capability to rapidly and automatically create a model configured to a disaster event, and to simulate a situation in standard data formats and structures. An *integrated Emergency Response Framework* (iERF) for further MS with data and architecture standards is defined via entities of interest (population, resources and response agents), disaster events (man-made technical and natural) and applications (vulnerability analysis, planning, identification and detection, training and response).

Mansourian *et al.* (in press) define disaster management as a cycle of activities including phases of mitigation, preparedness, response and recovery. Mitigation efforts refer to activities which reduce the vulnerability to the impact of disasters or reduce the probability of disasters occurring. Preparedness efforts refer to activities which prepare the society to respond to a disaster if it occurs. Response efforts refer to activities to address the immediate and short-term effects of a disaster. Recovery efforts refer to activities which bring society back to normal.

This Iranian-Australian research group (Mansourian *et al.*, in press) already has prototyped a shared access, collaborative use and web-based update of spatial data in disaster response following the Bam earthquake. They research rapid or at least timely collaborative decision-making. Their research focuses are standards, access networks and policies, including policies with respect to the inclusion and appropriate use of private and academic sector capabilities. Options are described for removing some of the existing barriers, and the prototype's architecture is depicted including mobile, replication and security components about spatial data only.

Mansourian *et al.* (in press) also provide for a concept of partnership between all of the emergency response organisations and a partnership model for spatial data collection and sharing. The reasons behind this are that no individual organisation can collect and keep up-to-date all required spatial datasets before the occurrence of disasters because the variety of requirements is unforeseeable, and no organisation assigned as responsible for data collection can collect and update all of the required datasets for all involved organisations during and after disasters. However, in reality Mansourian *et al.* (in press) state that the participation of organisations in sharing spatial data in an emergency operation center (EOC) is limited due to technical barriers such as standards and interoperability models as well as non-technical barriers such as social, cultural and institutional issues.

Mendonca (in press) analysed specific cognitive aspects of extreme event decision-making by different emergency response organisations and a coordination protocol called Incident Command System for team decision-making in unplanned-for contingencies under risk and time constraints: To manage extreme events, flexibility, especially on a cognitive level, is crucial to organisational resilience in order to address contingencies that have not been planned for. The 2001 World Trade Center attack confirmed earlier suggestions that emergencies routinely create non-routine situations and underlined the need to plan for improvisation, development and deployment of new procedures in real-time during emergency management.

Preparedness and ability to improvise is considered to be equally as important as plans. Opportunities for computational decision-making support for improvisation are:

- Support for information and the prediction of event propagation (prognosis).
- Support on when and how to depart from planned-for procedures (improvisation).

- Support for interaction among society, physical infrastructure and the emergency responders (communication).
- Support for interaction with comparable "referent" models of complex systems (real-time modeling).
- Reducing search time using divergent and convergent thinking tools (simulation).
- Support for collaboration, negotiation and data sharing (decision-making support).

Mendonca also specifies how "referents" facilitate team improvisation according to jazz music theory with the notion of a rough guide or framework used to guide cognition in the performance of improvisation. Such rough guides include existing themes and a body of fragments, forming a "referent" underlying format as a set of constraints which allows for different realisations from the same "referent". In emergency response this realisation may be a two-stage process: First, to recognise that no planned-for procedure applies to the current situation, and second, to develop and deploy new procedures in real-time on the basis of all available "referents".

Improvisation is described by Mendonca as the use of the "referent" underlying set of constraints that provide a "blueprint" or "skeleton" for improvisation. In emergency response this referent may be a set of standard operating procedures and routines learned from previous or current experience as the basis for a new course of action in an unplanned-for contingency. A computational model of cognition, functional ontologies and reasoning within a decision-making support system expresses abstract primitive actions combined into sequences. Opportunistic planning supports human problem-solving through incremental stages, assembling possible solutions from this "referent" library of cognitive and behavioural processes.

The key choice in the whole consideration (Mendonca, in press) is the decision whether or not to improvise: This requires problem finding both due to knowledge about the event and the organisation's goals and preferences.

The literature concerning our topic can be summed as

- A lack of bringing together the efforts of different agencies in a co-ordinated way (OECD, 2003),
- A lack of interoperability between emergency response planning, responders' training, response coordination and decision-making (Jain *et al.*, 2003),
- A lack of standards, access networks and policies, whereas a collaborative partnership between all emergency response organisations cannot be realised due to technical and non-technical barriers (Mansourian *et al.*, in press),
- A lack of flexibility on the cognitive level to address contingencies that have not been planned for through improvisation during emergencies (Mendonca, in press), and

– A lack of research interest in the fields of disaster and emergency, although response to disasters requires research and decision-making support concerning emergency plans as well as improvisation (Altay *et al.*, in press).

Similarly, in our case study we found and tried to solve problems of interagency co-operation, emergency planning and collaborative emergency management. We take these deficiencies in the current state-of-the-art of emergency management as the starting point and problem definition for our research:

– First we try to define a general standard process for interagency emergency management, focussing in line with Mansourian *et al.* (in press) on the phases of preparedness and response.

– Then we try to provide a standard process interface between all emergency organisations contributing to emergency management at any escalation stage.

– Finally we try to establish standard staff work procedures in the lead organisation or a co-ordination board between all emergency organisations.

– The solution we found is shown at an example with our case study in two Regions of Austria (Northwest and Southeast).

After that we discuss further development of our concept in the context of current research and suggest possible follow-up research directions.

1.2. Emergency management: regional, national, european and global preparedness

In order to provide for sufficient and timely reaction capabilities, a general standard process for interagency emergency management needs to be in place depending on the time and space dimensions of possible and probable emergencies. Every kind of preparedness includes normative prescriptions for the further actions to be taken, and emergency actions need to be based on the legal system of the area in which emergency preparedness is provided for.

Typically, for each hazard some governmental and non-governmental provisions are made on regional echelons. In addition to civil emergency organisations, insurances also provide financial support in emergencies if pre-paid. In case of large scale emergencies a wealth of *ad-hoc* organisations are usually established and pushed into action in order to provide aid from less affected areas to the population in areas suffering most from the emergency.

All non-governmental organisations are subordinate to governmental regulations, whereas all governmental organisations should leave some free space for non-governmental organisations to let them make decisions and act in order to get public benefit from voluntary and private aid initiatives. All of these organisations have different echelons, mainly in a hierarchical structure with strong internal leadership. The echelons of governmental civil emergency organisations are normally identical or congruent to communes, districts and regions within the government,

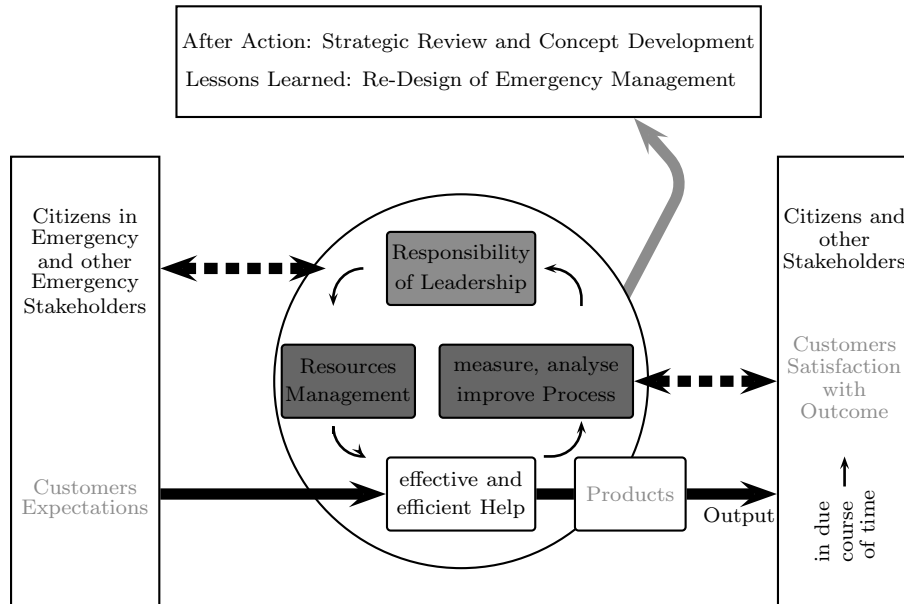


Figure 1. Business process elements within emergency situations. Adapted to *Emergency Management from ISO (2000)*

while the echelons of non-governmental organisations are not always congruent to the governmental echelons. Nevertheless, co-operation and coordination in times of emergency is required. Thus, a methodology is needed to organise preparedness and act on or react to cases of emergency.

We suggest looking at emergency situations as a normal business process, adopting well-proven management procedures when dealing with the expectations of citizens and other stake-holders in any emergency (see Figure 1).

Such methodology is often defined within Alert Regulations on a Regional Base, as local differentiation and habits seldom allow for a nationwide identical methodology and alert regulation. Nations normally ensure some National Standards within Alert Regulations, but not for regional alert regulations themselves. On European and global levels the main focus of civil emergency preparedness are Provisions for Border crossing Effectiveness because alert and emergency are normally not restricted to one of the specific governmental areas: Emergencies are cross-border situations on a regular basis.

International aid organisations are normally announced to be ready to act upon request from national authorities, and prepare themselves for different areas of operations in different nations. However, they have to obey to the same rules as set up by the respective nations where the emergency happens to emerge.

Up to date there have been no binding regulations or treaties ruling or limiting the execution of international aid given to nations. Nevertheless, there are some customary international procedures in case of really large emergencies. These procedures regulate how international aid is coordinated and brought into the emergency area (e.g. UN OCHA, donor conferences). We call the methodology of how to organise preparedness against emergencies *Civil Emergency Planning*. We call the methodology of how to act on or react to a specific case of emergency *Civil Emergency Management*.

2. Organisation of civil emergency planning (who and how to prepare)

2.1. Principles of civil emergency planning: government, NGOs, PVOs and IOs aid agencies

Every arising emergency develops over space and time. How to plan for evolving scenarios in general and thus find a standard process interface between all emergency organisations? Most aid is given on a voluntary basis, either by private voluntary organisations (PVOs) or other non-governmental organisations (NGOs) which may not be private and not completely voluntary as they may have permanent personnel, but all of them - also external governmental organisations giving aid to a specific emergency - have to consider possible emergency escalation and being affected themselves back in their homes. As the emergency develops, some organisations will be first on the location, others come late, some leave early.

When discussing some planning principles here, we are not undertaking a comprehensive approach, but focus on specific aspects of what we refer to as Planning Part C, the *Emergency Process Management*.

Planning "Part A": *Strategic Direction and Resources*

A first big part of planning has to deal with the preventive, pro-active legal, technical and cognitive security building measures as well as raising and providing resources according to valid emergency cases probabilities. We are not going to discuss this part here, but consider and assume the availability of results being in place.

Planning "Part B": *Operational Production Capabilities*

The next steps of planning are dealing with capability development, training, alert and escalation mechanisms based on spatio-temporal emergency case development scenarios including a solid concept of operations per each case scenario within each emergency organisation. The results are organisations which are individually capable to "produce" aid.

Planning "Part C": *Emergency Process Management*

Key planning efforts need then to clarify how to share workload between emergency organisations, how to properly co-operate via interfaces, and how to enable flexible use of capabilities per case scenario.

We started from this "Part C" of emergency planning in order to facilitate collaborative Emergency Process Management and provide for some decision-making support tools. One main goal of our research is to define a co-operation interface that would fit into most or all cases and scenarios. We then try to evaluate alongside of some spatio-temporal emergency case development:

- We looked at a specific emergency and the need for a single capability, developing over space and time.
- With the same emergency case we looked at the need for other single capabilities over space and time.
- Finally for that emergency we looked at the need for coordination and interfaces during co-operation.

Having done that for quite a number of cases we consider that we found a workable co-operation interface valid for *Emergency Process Management* in nearly all scenarios. This will be discussed in detail in chapter 3.

Planning "Part D": *Emergency Market Communication*

Furthermore, lots of planning is to be done on corporate image, the perception of emergency management effects and efficiency during emergency cases, operational analysis, situational awareness and controlling. The situational awareness regarding a customer's expectations and satisfaction with the aid provided is key. The main customers' body are the citizens who are possibly in an emergency, but there are a lot of other emergency stakeholders. As an example we look at a specific region and its real hazard-specific preparedness and provisions.

In order to give an impression of the complexity of the need for co-ordination we list those organisations which were included in the case study we describe later on (Table 1).

Such a rather complex variety of actors and stakeholders is the focus of emergency coordination and management. Furthermore, there is a widespread market of external supply and support to each specific region. We suggest considering external supply and support as a means of escalation, and to look at those suppliers just from the perspective of the next larger or neighbouring governmental administrative area, even across national borders. Each region which is prepared for inside emergencies

| | |
|--------------------------------|------------------------------|
| Political General Org. | Help Yourself & Self Defense |
| Public Awareness Org. | Immediate and Vital Needs |
| Civil Individual Org. | Economic Redundancy Policies |
| Industrial/Service Org. | Trade Org. |
| Public Service Org. | Stockpile Org. |
| Governmental Org. | Power Supply Org. |
| Nongovernmental Org. | Transportation Org. |
| Homeland Security Org. | Re-Construction Org. |
| Education Org. | Agricultural Org. |
| Evacuation Org. | Press/Media Org. |
| Health Emergency Org. | Police Org. |
| Medics, Paramedics, Veterinars | Military & NRBC Org. |
| Shelter, Bunker, Accomodation | Weather Forecast Org. |
| Firefighters Org. | Geologic Survey Org. |
| Flood Protection Org. | Mountain Rescue Org. |

Table 1. *Some example organisations included in civil emergency planning*

can utilize both roles of giving or taking aid: Whenever a region is directly affected by the emergency as discussed in chapter 1.1: That is the role to take aid - and all other regions which can give aid are in the role to give aid as external supply and support.

Thus, from this "Part D" of Emergency Market Communication arises some sort of market orientation for all other parts of planning, and looking at our specific planning aspect "Part C" Emergency Process Management without going into details we take advantage of defining the lead organisation among the vast variety of actors: The unequivocal main governmental authority of the region directly affected by the emergency which takes aid will be the lead organisation and coordinate all other organisations in order to supply and support. In some very specific cases in which the affected governmental authority itself may not be able to act accordingly, the next one-level-up higher governmental authority would lead instead of the directly affected one.

As discussed in chapter 1.2 up to date emergency lead is never taken by International Organisations (IOs), mainly for reasons of the existing legal systems. Maybe such a supranational emergency lead role will be realised on a European level in the near future for the first time, thus overruling different national legal systems.

Our text focuses on *Interagency Co-operation, Decision Making and Leadership* in the role to take aid only and to provide internal as well as external aid for internal distribution within an emergency area. It does not focus on logistics to bring aid in from outside.

However, just to learn from another attempt of co-ordination in the field of emergency management we looked at the initiative described by PAHO (1999) where

a software called SUMA (supply management) tries to support the other "side of the coin": The logistics of how to bring aid from outside donor nations into an emergency area. It is worth mentioning that this open source software is given for free to all donor aid organisations and receiving aid organisations in both Americas.

2.2. Principles of inter-agency organisation and planning

At this instance we try to define some standard staff work procedures in the lead organisation or co-ordination board in order to facilitate management and leadership while leaving participating organisations without mandatory major changes and with minimal modification of their respective organisational cultures and legacy systems.

Leadership within such a "volatile coalition of the willing" creates the utmost need for continuity in the first place. This means that especially information from the very beginning of the emergency must be documented and preserved exactly, and persons holding such information from the earliest stages need to be available throughout. Further on documentation remains an important task, and some continuity in personnel available should be granted.

Each organisation arriving at the location or in the area at first has to get into a *Know How Center* where situational awareness is produced and given: Specialists and experts contribute here to an overall assessment (see Figure 2).

Depending on the respective role assigned or self-assigned, all organisations will try to contribute to decisions made on how to deal with the situation. This *Coordination of Intent Center* is the most difficult step of *Inter-Agency Organisation*, and needs to be pre-planned, prepared and supported using decision-making support tools.

The next difficult step in this sequence is the *Resources Center* where there is an absolute and urgent need to know about all dedicated means available to the Emergency Process Management at any given moment. This is where all organisations have to and will contribute well if they are given suitable and affordable decision-making support tools.

The final step before assigning tasks and then going into action is the *Capability Center* where all single methods of each organisation as well as the collaboration capability between every pair of organisations two by two needs to be checked and balanced. The best solution would be to have regulations and standardised operational procedures (SOPs) written and hopefully also trained together during interagency exercises, but this is in reality seldom the case. The central part of coordination done here is to apply the rules of engagement (ROEs) given by law and by the lead government agency as discussed above in chapter 1.2. By those rules of engagement all participating organisations get some "does and don'ts" which can change over time by rule of law or government, even during emergency. This part of leadership possibly involves the most important legal aspects. Therefore, all documentation about collat-

eral damage and all following legal disputes about compensation will clarify who has or had exactly what right to act at any given time: This also needs decision-making support tools.

Normally there is not one single overall *Actions Center*, but perhaps several hot spots where most of the activity occurs at any given time. From all action spots the current situation has to be reported back to the *Know How Center*, where the situational awareness is produced and forwarded to participating organisations.

In parallel to all of the Emergency Process Management a *Media Center* has to be set up, where information is given to the public. Some information about the performance and progress (or lack of progress) of all actions needs also to contribute to a kind of Corporate Interagency Identity, which evolves from being together on the spot. In addition this is an important duty area of leadership within inter-agency organisation and planning.

Important to Emergency Process Management seems to be that there is obviously no or little direct command authority but a process of negotiating contracts while running this Inter-Agency Leadership (see Figure 2).

This sometimes leads to inefficiencies and overall ineffectiveness, compared to strictly top-down organisation. On the other hand, there is no business process model available ensuring voluntary giving-of-aid effectiveness. Leadership therefore will function mainly through incentives and the reporting of measures of effectiveness to the public. This also corresponds to lean management theories which focus on systems thinking, partnership processes, customer relationship and bottom-up service orientation instead of mainly top-down command and control (Seddon, 2003).

3. Organisation of civil emergency management (who + how to act)

3.1. Principles of inter-agency decision making and network enabled management

Once planning is completed and preparedness is given at any time, emergencies would be dealt with accordingly. Decision making during the rather strained, chaotic and emotionally demanding atmosphere of a real emergency needs to be done as close to the procedures as possible which were set up during planning and preparation phase.

For operation a threefold dynamic process is run, including intelligence cycle, decision cycle and targeting cycle. The fourth usual step of controlling (Plan - Do - Check - Act) is not put separate in the workflow but seen as part of decision cycle, and measures are done within intelligence cycle whenever situations change (see Figure 3).

Intelligence can be described as getting situational awareness as close to reality as possible and preparing for well-informed decisions by tracking the most important

Lean Leadership for Interagency Operations

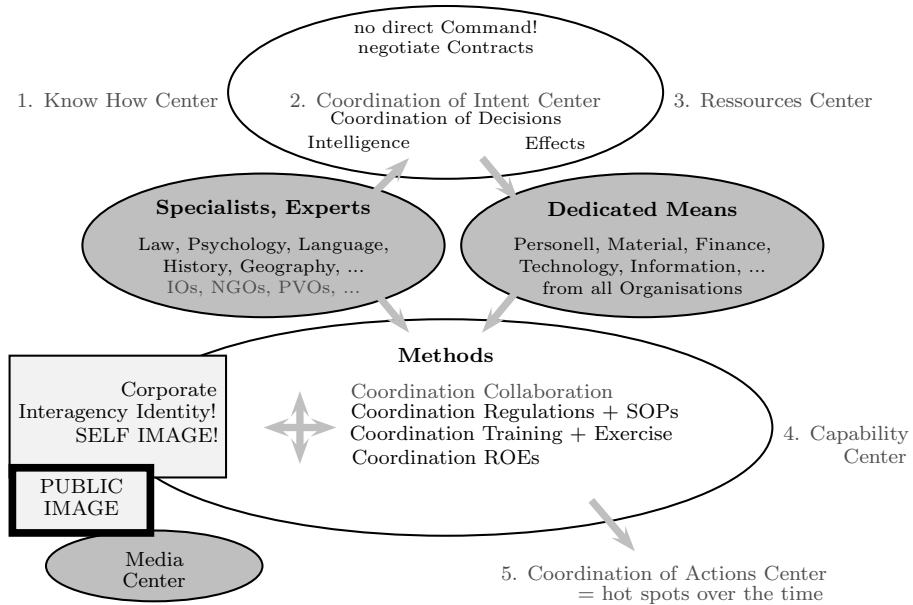


Figure 2. Inter-agency leadership within emergency management

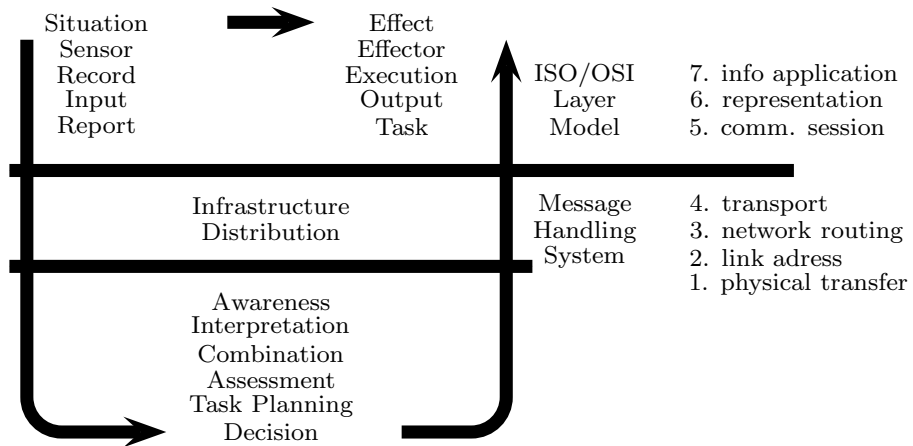


Figure 3. A threefold dynamic process supported by networking infrastructure. Adapted to Emergency Management from ISO (1988)

objects (units, assets, targets) within area of operations as well as doing reconnaissance in the field whenever situation becomes fuzzy (uncertain, vague, frictional¹) or having "science in the loop" (market research, expert pool) whenever it comes to interpretation (see Figure 3).

Targeting can be described as pushing desired effects into reality and executing actions or reactions in order to influence the development of the emergency situation. The targeting cycle relies heavily on intelligence and situational awareness. Assigning tasks to emergency organisations has to be done in close spatio-temporal coherence with knowledge about current decisions and intelligence. Nowadays network capabilities provide for "Near Real Time" data available to every emergency organisation, but this data load would be data overload if not processed and put into context of a comprehensive recognised common operational picture (see Figure 3).

Thus during each interagency operations decision cycle the network infrastructure can be utilized for enabling a reach back from decision makers in the field into a properly prepared knowledge management data base, including standby expert pools ready to assist in the assessment of situation, interpretation of data and applying available state of the art knowledge onto the developing emergency situation from apart distance.

3.2. Putting the pieces together: a best practice case study of network-enabled management and lessons learned from practice so far

So far we described:

- a general standard process for interagency emergency management,
- a standard process interface between all emergency organisations and,
- standard staff work procedures in the lead organisation or co-ordination board between all emergency organisations.

Now we describe in detail our case study in two regions of Austria: Three districts and a total of seven community areas were involved in our field experiments. The above-mentioned emergency planning and responsibility for the overall business process rested with the Federal Ministry of the Interior.

The leadership for interagency operation during emergency management rested with the two regional government offices where our suggested staff work procedures were executed by a team from each contributing emergency aid organisation including IOs and NGOs following the suggested staff organisation and workflow. Most of all resources and capabilities for the effective production of aid to the civil population in the area were brought in and exercised by each emergency organisation at community

1. See the broad and interdisciplinary discussions on Friction, Chaos, Complexity as proposed by Clausewitz (1832).

area level with leadership on a district level. We tackled the co-operation and interoperability problem by making available network-based data with a spatial and attribute data interface messaging infrastructure.

Through these network-based tools we trained the staff teams of each emergency organisation in making parallel assessments of situations (various fictitious catastrophic scenarios that required the cooperation of organisations) instead of waiting for the arrival of the estimation from the higher or lower echelons. The thin client we gave as a front-end application proved very helpful. This was also given to each mobile platform of each emergency organisation if there was the equipment to communicate with wireless digital data transfer.

Thus we had a very inhomogeneous hardware environment, but a standardised data and software interface when minimum requirements were met by the hardware. As each organisation was equipped differently and sometimes did not meet the requirements, the network was far from being complete as conceptually anticipated. So the question of usefulness and effectiveness of primary data input and output on different organisational levels arose, but could be answered clearly positively. Having described the principles and some theory of *Civil Emergency Management* we will now give a short example for the real availability of Networking Infrastructure in order to gain a common understanding for the decision support environment we have to consider at this time and in this market place.

Figure 4 shows an example of three Emergency Organisations, named X, Y and Z, with Organisation X being the only one with few digital wireless communication equipment pieces in the field (one individual, one car, three operational elements) and running a communication server at a Local Area Network (LAN) networking infrastructure which connects and supports four different staff members of Organisation X, called S1/X through S4/X.

These staff members are given specific duties in the management and decision-making support to Organisation X: S1/X has to deal with personnel, S2/X with threat and damage during emergency, S3/X covers all tasking and effectiveness issues, whereas S4/X works on material and logistics.

In addition the two other Emergency Organisations Y and Z have only one piece of digital communication equipment. Due to reasons of practicability, each are connected to the communication server of Organisation X. On the higher echelons there are two district level workers, called Staff A and Staff B. They do not run a separate *Communication Server*, but are connected to the highest depicted headquarters, called HQ SE, which is running a Wide Area Network (WAN) at regional level (not described in more detail here).

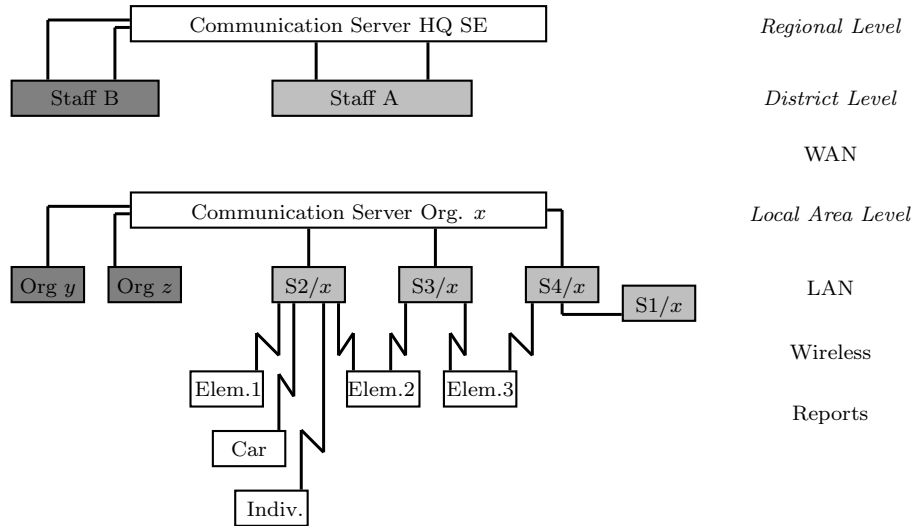


Figure 4. An example of networking infrastructure availability

Under such inadequate and incomplete networking conditions there is a great need and room for improvement on the equipment side, but nevertheless it already does make sense to support the few staff members and put forward whatever reports would come in, normally using very different digital formats and media.

Figure 4 also shows the most difficult question of interagency operations management: Who will be running the staff cycles from intelligence to decision-making to targeting? Currently the Organisations X, Y and Z as well as Staff A and Staff B and finally HQ SE often run situational awareness separately.

4. Decision making specific: "Inter-agency" decisions and effective leadership?

4.1. Leadership, staff expertise and operational effectiveness

Since every single organisation needs a specific staff assessment at all different echelons, this workflow of separate assessment does make sense and will not be abandoned at any time in the future. However, if a common networking infrastructure is made available to all of them there would be a lot of burdensharing and time-saving as well as quality improving synergies among all of those organisations.

The next questions would be: What are the staff doing all the time, what needs to be done separately in future, and what could be shared or done together? This question will be discussed in the remaining portion of this paper.

The decision cycle to be described a bit more in detail is similar to the Civil Emergency Planning Process in General, but focussed here on short notice, and embedded into the Emergency Situation.

- It starts from Situational Awareness, which is the result of the Intelligence Cycle as described before.

- Next is Operational Planning, which is the assessment and target development phase including making use of reach back assets and capacities if available.

- Tasking is central. This is when interagency organisations and units are assigned or coordinated to forward specific intended effects onto the Emergency Situation in the field.

- This tasking is rather more to Contracting or Diplomatic Activity than to Commanding.

- The last is control, which previously was mentioned as being overestimated in most classical management theories and business process models. We see it as "closing-the-loop" from Effective Operations in the field via Reporting back to a sensor-supported Situational Awareness.

In the decision-making cycle the result of operational planning needs to be shared in any case, as tasking or even self-tasking needs to be known to every entity and organisation active in the field of emergency to prevent them from hindering each other, and to enable spatio-temporal coordination, at least when the use of public infrastructure like roads, water, electric power consumption or similar is planned.

In general, any intent or interest present in the stake holder community or environment of the Emergency Site needs to be aware of all or at least most of the actors providing aid there under very dangerous circumstances. Whether or not situational awareness can be shared will be discussed and decided every time at any emergency case, as so far there is no workable technical solution for a common operational picture at interagency operations. As long as there is no common technical solution the need for some additional workload in order to share this information also has to be considered: That is why up information sharing is not very common to date.

Another problem about information sharing is the question of whether or not a task can be given to an individual element of one organisation by a person not belonging to that organisation. This is considered to be one of the crucial points of interagency operations and will be solved only by the exchange of sufficient amount of staff members so that when assigning a task to e.g. firefighters, every single echelon will have a fire fighting staff member or otherwise will not be able or allowed to give a task to a fighting unit.

From this exchange of staff members between different organisations two main conclusions can be drawn:

– First, it is true that assigning an effective operational task to any specialised unit requires an adequately specialised staff member at the target planning and tasking echelon one level above.

– Second, it becomes difficult whenever a number, e.g. maybe more than ten or even more than twenty, specialised organisations have to co-operate in a specific emergency case.

The question of how to specialise one staff member to be able to deal with two or three differently specialised types of units can be put aside as being pointless in the long run: Basic knowledge and staff expertise are required to assess capability and proper tasking for each type of unit, and any compromising of this basic assessment capability will compromise the effective use coming from this unit.

Thus, in general we have to live with a large number amount of staff members. This leads to the conclusion that we will not afford and even do not want to afford such a large number of staff at more than a few places at a time. The last aspect about information sharing during interagency operations is the question of controlling and measures of effectiveness. That point is still under consideration in general terms, because under time pressure one has to consider honestly whether or not (and if so then to what extent) we want to invest and "waste" manpower, time and effort into controlling where at the same time urgent aid to human beings needs to be provided.

The final answer to controlling under emergency conditions is not yet clear. There will be something about controlling in the field. In the long run there will be a tradeoff between lack of resources and lack of time on the one hand versus lack of documentation and traceability on the other hand.

A workable compromise could be to have a qualified and standardised Lessons Learned Documentation and Emergency Market Research at the end of each emergency case.

4.2. The interagency paradigm: worst case and parallelization of overall effort

Last but not least on the subject of interagency operations the overall effort put into coordination must be considered so that the effort at the management level is not more than suitable for running efficient operations at the base. As experience tells us, the most efficient emergency aid is usually provided when the case is the very worst. Therefore, we have to learn that all effort in coordination needs to have a small footprint, and all the different specialised organisations need to keep their profile of specific use for the very special problem they are specialised for.

Networking technical solutions which help to share information and build near real time situational awareness will shape the future of interagency operations. The one step we are making here is to make a basic interface tool available (for no charge) to all organisations having little infrastructure but an urgent need for situation updates.

The next step needs to be done by the organisations themselves in order to provide for a more parallel, asynchronous and flexible assessment process shared among all echelons and organisations in real time (see Figure 5).

Looking at the information flow in the worst case there is still well-structured information coming from each emergency organisation in the format of normal reports towards an integrated staff at medium level. On the other hand, there is a lot of relevant information coming from the population in an unorganised, chaotic form and we do not know in advance what will be useful information, and what will not.

All information needs to be collected and assessed. This is where information technology can help considerably when receiving vast amounts of information and sorting it by a few criteria. One important criterion is sorting by location, and thus location needs to be added to every single piece of incoming information. Therefore, information has to flow to the staff and will be assessed at each staff member's workplace in his or her specific field of competence. Outgoing information is reduced, but the quality is increased significantly. Every single contribution of staff members to the situational picture will be stored in a database, available to all organisations in a structured way reduced by staff expertise, sorted by the origin of the information. Now all organisations can look at those pieces of information at the same time. This is a big advantage compared to the situational awareness they have without that decision-making support tool.

In addition each organisation is asked at every single time slot to add their respective assessment of the situation to the database. If this is done on a regular basis, the individual effort necessary to do this is small, but benefit to the overall emergency case is great. Each time slot of current information will be archived, and the process restarts. In order to have organisations following that guideline, one of the main and most important coordinating leadership decisions is to define a specific time slot period in which assessment and reporting has to be completed on a regular basis.

- For emergencies with fast dynamics and quick development, the assessment time slot may be every 3 to 6 hours, forcing every organisation to give a written assessment per each hot spot or emergency area.

- For emergencies with slow dynamics the time slot will usually be every 12 to 48 or even 72 hours only.

Whenever all participating organisations have entered their assessment into the database, the integrated common staff echelon, perhaps as depicted here on the district level, will not have to have a specific qualification in every specialized regard to assess the large amount of data coming from all areas, but can build upon the assessment of all subordinate specialised organisations and units in all respective areas (see Figure 5).

In general the specialisation at the lower level is still high in order to have expertise at the location. At higher echelons networking allows the assessment to be based on expertise not inside the staff and thus releases personnel to the places where they are of immediate use for those affected by the specific emergency case.

An additional option which may help give an overview and quick insight into the situation at the Know How Center can be to visualise the amount of information coming in at the current time slot on the map, using the location as the reference and putting the size of some symbol according to the amount of input information (circles at the map in Figure 5).

What we do not describe here in detail, but leave to another part of our research documentation is the architecture and design of our software front-end. However, we consider it essential to mention the fact that all parts and modules we produced, used and proved useful were purely open source software which was given free of charge to the participating emergency organisations. Similar to the aforementioned logistic solution SUMA by PAHO (1999) we create a possibility for broad and deep use of network-based tools in the "community" of all emergency organisations and even the private interest of individuals to cope with the tool, train and learn between the emergency situations and also provide feedback.

5. Conclusion

We described shared or parallel information processing and network-enabled procedures between all involved emergency management organisations supporting decisions under time constraint, and pointed out the need for an open source software strategy to maximise use, also by voluntary small NGOs. Without describing the design of the system in detail, we presented the structure of a computer-network based decision-making support tool for the cooperation of organisations in emergencies. The implemented application was tested in communities in Austria and was evaluated by practitioners. The feedback generated in these sessions will be considered for the future versions of this software.

A final point we touch upon but do not solve in the approach we took towards emergency process management is the problem of time pressure. This is inherent when making a decision during an emergency situation. It is not solved yet. Automated decision support normally takes into consideration the information requirements of the respective leadership echelon, puts all information together and presents either a good overview over the data and information or even a qualified prognosis.

Information systems normally need to have a specific quality and quantity of input information in order to be able to produce reasonable output information - otherwise the saying is true: garbage in - garbage out. When speaking about real and dangerous emergency situations we have to be aware that decision-making saves lives and prevents damage, so every decision that will be taken needs to be taken

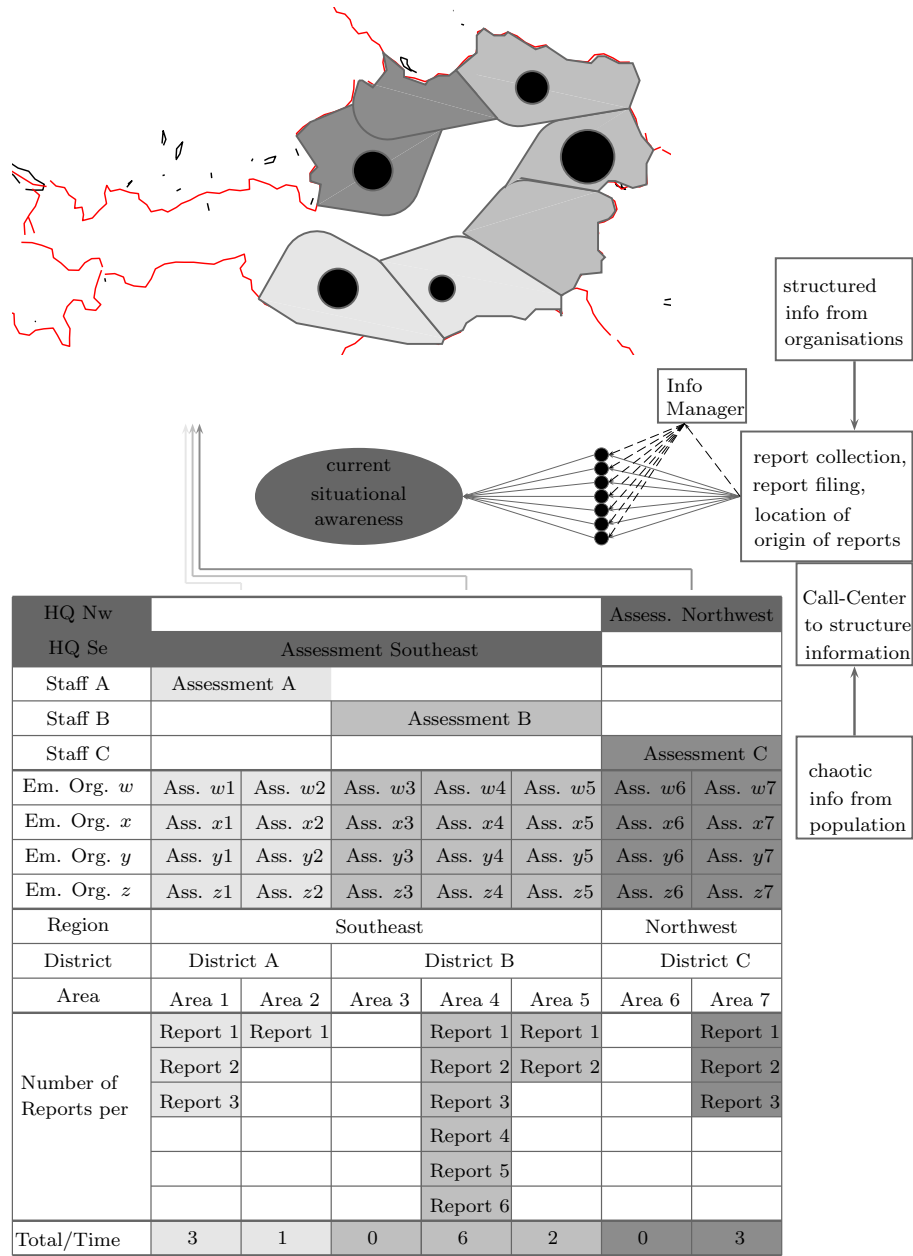


Figure 5. Parallelization of overall inter-agency effort

fast. To provide information about the lack of information is the first and maybe most helpful step towards artificial emergency leadership, but real assessment about life saving assumptions cannot be provided automatically yet. Thus, further work towards prognoses based on a lack of information when supporting decisions under time-pressure needs to be done.

6. References

- Altay N., Greene W., "OR/MS research in disaster operations management", *European Journal of Operational Research*, in press. corrected proof available online 24.8.2005.
- Clausewitz C., *Vom Kriege*, Berlin, 1832.
- ISO, "International Standardization Organisation 8648:1988: Information processing systems - Open Systems Interconnection - Internal organization of Network Layer", 1988.
- ISO, "International Standardization Organisation 9001:2000: Quality Management Systems", 2000.
- Jain S., McLean C., "A framework for modelling and simulation for emergency response", *Proceedings of the 2003 Winter Simulation Conference*, New Orleans, Louisiana, USA, pp. 1068-1076, 2003.
- Mansourian A., Rajabifard A., Zoj M. V., Williamson I., "Using SDI and web-based systems to facilitate disaster management", *Computers & Geosciences*, in press.
- Mendonca D., "Decision support for improvisation in response to extreme events: Learning from the response to the 2001 World Trade Center attack", *Decision Support Systems*, in press.
- OECD, "Emerging Systemic Risks in the 21st Century - An Agenda for Action", 2003.
- PAHO, "Humanitarian Assistance in Disaster Situations. A Guide for Effective Aid", 1999.
- Seddon J., *Freedom from Command and Control: A Better Way to Make the Work Work*, Buckingham, 2003.
- UN ISDR, "United Nations International Strategy for Disaster Reduction, Living with risks: a global review of disaster reduction initiatives", 2002. See also: <http://www.unisdr.org/eng/library> - visited November 2005.

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