

The Borsele Files: The Challenge of Acquiring Usable Data under Chaotic Circumstances

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ABSTRACT

Conducting empirical research involves a balancing act between scientific rigor and real-life pragmatics. DECIS Lab researches systems-of-systems, consisting of humans and artificial systems involved in collaborative decision making under chaotic circumstances. An important objective is the usefulness of our results to our major application domain: crisis management. DECIS Lab was involved to set up a crisis management exercise experiment and according measurements regarding an improvement in internal communication at Gemeente (Municipality) Borsele. In this paper the empirical research regarding this experiment, the methodology and its results are briefly outlined. Our main lessons learned concern the interrelationship between scenario, experiment and measurements; the problem of acquiring usable data; and the challenges of conducting grounded research.

Keywords

Crisis Management Exercise, Empirical Research, Experimental Methodology, Lessons Learned.

INTRODUCTION

Multi-disciplinary research which aims to address real and future needs cannot afford to be restricted to an 'ivory tower', lest its results be very interesting but not necessarily useful. Empirical research is an approach to embed practice (or: reality) in such research, by involving both researchers and practitioners to conduct experiments in the practitioners' context. Such a joint approach has as overt benefits that researchers on the one hand become acquainted with real needs and desires and practitioners on the other hand become inspired by future possibilities. To stimulate empirical, or grounded, research, Dutch ministries which fund research require 'valorization' to take place: (potential) societal benefits from research results have to be proven. DECIS Lab and Gemeente (Municipality) Borsele have teamed up to conduct empirical research in the context of a crisis management exercise.

DECIS Lab is a multi-disciplinary open research partnership of Thales Nederland, the Delft University of Technology, the University of Amsterdam and the Netherlands Organization for Applied Scientific Research TNO. DECIS Lab's research combines Human Sciences and Information & Communication Technologies in a quest to shape human cognition and artificial intelligence into the best collaborative problem solver: Actor-Agent Communities for decision making in chaotic environments. This research focuses on systems-of-systems, consisting

of humans and artificial systems involved in collaborative decision making under chaotic circumstances. Our major domain of application is crisis management, in which decision making takes place under time pressure, is based on uncertain, incomplete and conflicting information, consequences of decisions cannot be foreseen, and the environment changes in unpredictable ways.

Gemeente Borsele is one of the important locations in Dutch crisis management. The small municipality (a rural municipality of 22K+ citizens in fifteen villages) is contrasted by its high-risk objects, including a nuclear power plant, petrochemical industry, the major shipping lane for the port of Antwerp (the Westerschelde), and the entrance of a toll-tunnel underneath the shipping lane (the Westerscheldetunnel). The municipality is the prime responsible to manage crises for these objects in the province of Zeeland. Gemeente Borsele’s crisis-management capacity is related to the small number of citizens, which is in sharp contrast with the costs of mitigating the potential crises. The land is partially below sea-level, has small dikes (‘waterkeringen’) segmenting the territory and is protected from the sea by major dikes (see Figure 1). Gemeente Borsele actively works on its crisis management skills, both on the level of individuals and of the organization as a whole. The last large-scale Dutch crisis management staff exercise revolved around a nuclear accident in the Gemeente Borsele’s nuclear power plant [1].

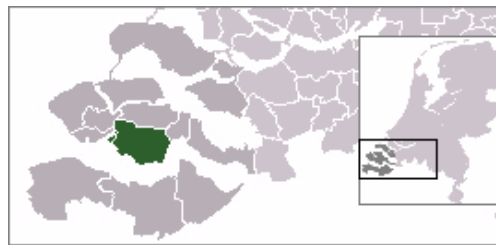


Figure 1. Whereabouts of Gemeente Borsele in Province Zeeland of The Netherlands.

In our view of empirical research, it is of paramount importance to make the objectives of the participants explicit and collaboratively define an approach in which the most important objectives are addressed. DECIS Lab basically has three main objectives: to collect data from real crises, to acquire domain knowledge and to discover the feasibility of analyzing and evaluating the obtained data. Gemeente Borsele has two major objectives. The first is to improve the internal communication in their organization. The Gemeente Borsele expressed an interest in the role and functioning of their ‘Berichten Centrum’ (message centre); an action centre primarily used during crises. This action centre distributes and disseminates all internal and external messages to and from the Gemeente Borsele. The second objective is to involve the entire internal crisis management organization in the exercise. This specifically includes involving municipal action-centers (“actiecentra”) for housing, environment, legal issues, civil administration, etc. (see Figure 2) for a total of 13 organizational units involved [2]. In general, action centers are a means to manage the municipal crisis management organization separate from their normal organization. Nevertheless, action centers are usually physically located within a regular department and staffed by employees from such a department. The majority of the action centers are located within the city hall.

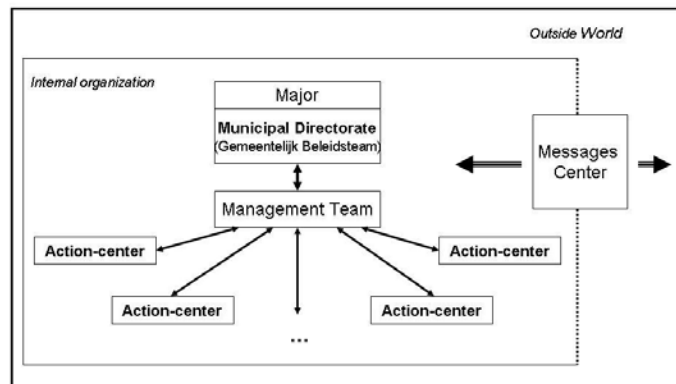


Figure 2. Structure of the Borsele crisis management organization (source: [2]).

By joint agreement, the first experiment had to be at an entry-level ('deurmatniveau')¹ for crisis management, so that a common frame of reference can be constructed. The focus of the empirical research and the exercise is on communication by messaging: 'focus op berichtenverkeer'. For this purpose, a standard message template is to be introduced, with which a number of known issues in the internal communication can be tackled. The standard message template (see Figure 3 for the Dutch version) is, among others, intended to improve clarity of the message header, facilitate distinctions between sender, receivers for action, and receivers for information. This template is to be used in substitution for all other scrap-note papers or other communication: it is to be used for personal notes/loggings and to be attached as a cover to other means of communications, such as faxes. *Our hypothesis* is that through introduction of a well-structured paper-based template messages are more efficiently distributed through the organization and this result can influence future ICT changes.

Standaard Berichtenformulier Gemeente Borsele

Tracking no:
NW-09-51

OEFENING Focus op Berichtenverkeer

Nummer:.....
Prioriteit: **Routine / Spoed**
Bevestig ontvangst:..... **Nee / Ja**

Afzender		Geadresseerden	
Organisatie		Actie:	
Opsteller:			
Vrijgegeven:		Info:	
Paraaf			
Datum/Tijd: - / ~		Datum/Tijd ontvangst: - / ~	
Kenmerken	Onderwerp:		
	Verwachte acties:		
	<input type="checkbox"/> Opdracht <input type="checkbox"/> Besluitenlijst <input type="checkbox"/> Verzoek <input type="checkbox"/> Situatie Rapport <input type="checkbox"/> Voortgangsrapportage <input type="checkbox"/> Bevestiging van ontvangst van bericht nr.:		
Bericht			

Figure 3. Standard message template in Dutch.

In the original intent, initial explorative field research is to provide additional insight into the organization, after which two crisis management exercises are to be conducted with a period of several weeks in between. The first exercise is to be held without the template, after which the standard message template is to be introduced, and its effect is to be measured in the second exercise. The advantages of this setup include a sound comparison, extensive introduction of the template and fine-tuning the necessary measurements for the second exercise. The original intent was not feasible², as only a half-day slot was available for a large-scale crisis management exercise in fall 2006. Subsequently the original intent has been modified to suit this half-day, as high importance is given to obtain data regarding situations without and with the standard message template.

The scenario for the crisis management exercise and –experiment has to fit both parties' objectives and constraints, as mentioned above. By agreement, a flooding scenario was preferred over a nuclear scenario; the latter has too

¹ The Gemeente Borsele explicitly formulated that they did not want any major changes to current organizational matters, and above all no introduction of any new Information & Communication Technology (ICT). As such we have refrained from any suggestions to any existing or new technologies and these are therefore not within the scope of this paper.

² Unfortunately, the initial explorative field research, intended to investigate the needs, desires and practice of (crisis-related) communication did not take place; both the development and acceptance of the standard message template as well as the results of this exercise would have benefited.

often been exercised lately. Although usually a scenario has a build-up in intensity regarding threats becoming a crisis over time, an alternative approach was chosen. The scenario concerns flooding of one the villages, Ellewoutsdijk, which occurred a number of days *before* the exercise takes place; the disruptive event has already happened and consequences need to be managed. In the second half of the exercise a dike of another village, Hoedekenskerke, is threatened: the more usual build-up of intensity. This construction has the advantage that the entire municipal crisis management organization is engaged immediately from the beginning of the exercise – the most constraining objective regarding scenario construction. The participants in the exercise were briefed that they formed a new shift for managing this crisis and had to start from the open actions and decisions from the previous shift. The outside world for the Gemeente Borsele was enacted by the exercise control ('oefencel') which used a detailed scenario to provide the participants with (prepared) stimuli and react to the participant's actions.

This paper reports on our experiences with empirical research. In the next section, the methodology is outlined, including the overall structure of the crisis management exercise and experiment, and the different measurements to be taken. Subsequently, the results are summarized, with emphasis on both quantitative and qualitative results. The paper concludes with a discussion and lessons learned.

METHODOLOGY

Overall Structure

The experiment that was conducted is by all means a naturalistic experiment in which...

"(...) you contrive to collect experimental data under natural conditions. You make the data happen, out in the natural world (not in the lab), and you evaluate the results." (Bernard, 1995, p. 58)

As explained previously, the crisis management exercise took place in only a half-day. The day began with a general briefing in which the participants were welcomed, the presence of the DECIS Lab and their observers was explained to them, and the participants were given a number of instructions. Subsequently, the first (hour-and-a-half) session of the day began, followed by an intermezzo of 30 minutes to explain the standard message template to the participants, and to answer the questionnaire about the first session. The second session also took 1.5 hours, after which the participants answered the second questionnaire, received a lunch, and had a chance to discuss their experiences. The DECIS Lab observers and exercise control were debriefed separately for another two hours. The schedule of the day is summarized in Table 1 below:

Time	Event
08.30	General briefing for all participants
09.00	Start of exercise: Session 1
10.30	Exercise on Hold: Introduction standard message template & questionnaire 1
11.00	Continuation of exercise: Session 2
12.30	End of exercise & questionnaire 2
13.00	General Discussion with Gemeente Borsele's participants
14.00	Debriefing Observers DECIS Lab & exercise control
16.00	End

Table 1. Global timetable of the crisis management exercise.

Measuring quantitatively

Measuring the entire communication flow in reality was challenging in the context of this exercise. Our approach was two-sided: (1) the focus of the measurements lay on the quantitative gathering of *all* the information about the exchanged messages, and (2) in addition participants were asked to answer a (qualitative) questionnaire about their opinions on several aspects of the exercise.

In the quantitative approach the interest lay in capturing the 'sender', 'receiver', 'content of the message', and the 'time the message was sent and received'. The scenario was constructed such that all events were unique with respect to the combination of location, subject/topic and person/company. The objective was that every message traveling throughout the organization could be unambiguously labeled and related to the unique events. There were,

for example, one Propane Gas Tank, one leaking roof in a shelter and one group of German high school students³ as events in the scenario. The means to capture this information were: logging and observing.

1). *Logging*. The extent of logging during this exercise is shown in Table 2. To facilitate handling all the paperwork two colors of paper were brought into the exercise: blue for the first session, and yellow for the second session. The different kind of templates that are part of the crisis management routine of the Gemeente Borsele were also printed in these colors and handed out at the beginning of the sessions. All e-mails that were exchanged between the Municipal Directory, Management Team, the Messages Center and the different action-centers were automatically logged. The logging of telephone conversations was technically impossible during this exercise.

2). *Observing*. To ascertain that we could record as much as possible, the DECIS Lab Team was extended with 20 observers. A week before the exercise they were given an introduction about their role and function. Each observer was assigned to a specific team/action-center. The objective of the observers was to record *every* exchange of messages that took place at ‘their team’. The observers were given specific forms on which message exchanges can be recorded, with options to describe who the sender/receiver was, time of arrival of a message, message type, etc. In addition to this the observers distributed and collected the questionnaires after each session, and introduced the standard message template.

Extent of logging		
<i>Communication / logging medium</i>	<i>Description</i>	<i>Logged by DECIS Lab, or not?</i>
E-mail	E-mails between action-centers and teams	Logged
Personal log	Written log by an individual participant in which his/her conversations and decisions are recorded	Logged
Telephone log	Written log by an individual participant in which his/her telephone conversations are recorded	Logged
Sitrap	‘Situation Report’ in which an organization gives the latest update about the situation tot their crisis management partners	Logged
Decisions List (‘Besluitenlijst’)	Decisions List of a Municipal Directorate or Management Team, to be internally distributed	Logged
Conversations	Discussions within and between teams	Partially audio-recorded, not transcribed
Face-to-face conversations	Face-to-face conversations between participants	Not logged
Mobile phone call	Personal mobile telephone traffic	Not logged
Regular telephone call	Regular telephone traffic	Not logged

Table 2. Extent of logging.

Measuring qualitatively

In the questionnaire (handed out to every participant after each session) participants were asked to reflect on:

- Decision support (usage of ICT means & contingency plans);
- Collaboration (collaboration within a team, between teams and within the entire organization);
- Workload (ability to perform one’s task, amount of routine);
- Timeliness/completeness of messages (features of used message templates: are the sender, content, urgency, etc. easily understandable?);
- Task execution (satisfaction with functioning of team and organization);

³ The province of Zeeland is a popular holiday destination for Germans, due to the sea and beaches.

- Availability of information (acquisition of information);
- Situation awareness (having a continuous overview over, and insight in, the crisis situation).

Each of these categories was operationalized by several questions in the form of propositions on which the participant could indicate whether he or she found that proposition to be ‘not the case’, ‘on an average’ or ‘much applicable’ or ‘not applicable’ to his/her own situation. These answers were to be indicated by (respectively) 0 points, 5 points, 10 points, or an ‘X’ if the proposition would not apply to the respondent. Examples of propositions (translated from Dutch) are: “The information I have received was understandable”, and “The urgency of messages was clear to me”⁴. Both questionnaires consisted of 35 propositions and of an option to give extra comments on the previous exercise session. The second questionnaire was slightly different in that it contained a number of additional questions to compare both sessions plus a section asking participants’ comments regarding the standard message template.

RESULTS

Exercise: Overall impression

After a plenary briefing to the day’s exercise, all 80 participants and 20 observers went to their respective rooms in the building. They immediately started managing the crisis – although getting acquainted with the situation took some time and effort. It was interesting to see how quickly people became involved, as if it were really a crisis. A few general observations are noteworthy to mention. First of all, there is an abundance of paper being shifted around in the entire crisis organization, written communications arrive mainly by fax, and the majority of communication actions are by (mobile) phone and e-mail (see Table 3 below). The amount of paper messages and the (telephone) conversations made it difficult for the observers to record all the messages that are passed between people. Second, the participants took their roles so seriously that they found the break in the middle of this exercise very annoying, up to the point that some people got angry. They refused to stop managing the crisis to be instructed regarding the new standard message template, and they were upset by having to answer the questionnaire because they had to temporarily suspend their role. Ergo: intrusions should be avoided in an ongoing exercise.

Data Analysis: Quantitative

Approximately 783 logged communication actions were recorded during the entire duration of the exercise (3.5 hours in total), 327 in session 1 and 456 in session 2 (see Table 3).⁵ This is an accurate number regarding the data gathered, which is an approximation of the real message traffic during the exercise. Also shown in this table are the numbers for different types of messages (E-mails, Personal Logs, Telephone Logs, Situation Reports and Standard Message Template) that circulated through the organization.⁶ Analysis of the resulting dataset proves to be a difficult task, first of all because the data are incomplete, which is often the case in naturalistic datasets.

	Total Number of messages	E-mail	Personal Log	Telephone Log	Situation Report	Standard Message Template
Session 1	327	81	34	187	12	--
Session 2	456	134	31	179	30	76
Total	783	215	65	366	42	76

⁴ Dutch translations: “De informatie in de berichten die ik ontving, was duidelijk”, and: “De urgentie van de berichten was duidelijk”

⁵ Duplicate messages are eliminated from the counts; e.g. an e-mail sent by one party and received by another are 2 log entries, but constitute 1 communication act.

⁶ Note that the total number of all message types does not add up to the total number of messages, because there are also a few other types of message, such as name lists, decision lists, etc. For reasons of brevity we omitted those numbers here.

Table 3. Partial overview of communication actions for the most indicative message types⁵.

To ascertain whether the introduction of the standard message template improves or changes communication and whether it improves the crisis management process, messages pertaining to the different events were traced throughout the organization, by mapping the senders and receivers of each of those messages. However, from the logged messages it was often unclear whether a message concerned a sent or incoming message. E.g. from the telephone logs it was difficult to trace whether a person had made or received a call. Moreover, for the greater part of the communication acts, it was difficult to ascertain if the communication was ‘completed’. By this we mean that if one message concerned, e.g., a request for information from party A to party B, we couldn’t trace if party B had indeed provided the requested information. In addition, if a party was in need of certain information this is not recorded (unless explicitly stated in a communication) nor can it be determined afterwards in the analysis phase.

This missing information is actually one of the points to take into account by the municipality: people don’t record very well, even though they think they do, as is exemplified by the participants’ questionnaire response; The participants claimed good logging practice, as can be seen from their agreement with the propositions “I kept a logbook of all communications (also telephone calls)”, and “I made sure that communications (including telephone calls) were sufficiently logged in order to afterwards give accountability for the course of events” (see figure 4 below, in which respectively 52 and 65% of the respondents indicate ‘good logging’). Although participants often claim good logging, as humans in general overestimate their own capabilities, logging is often not evaluated afterwards. In this exercise, evidence is found that logging needs to improve; currently a (hypothetical) governmental inquisition investigating the “Borsele flooding and evacuation” would not be given sufficient information.

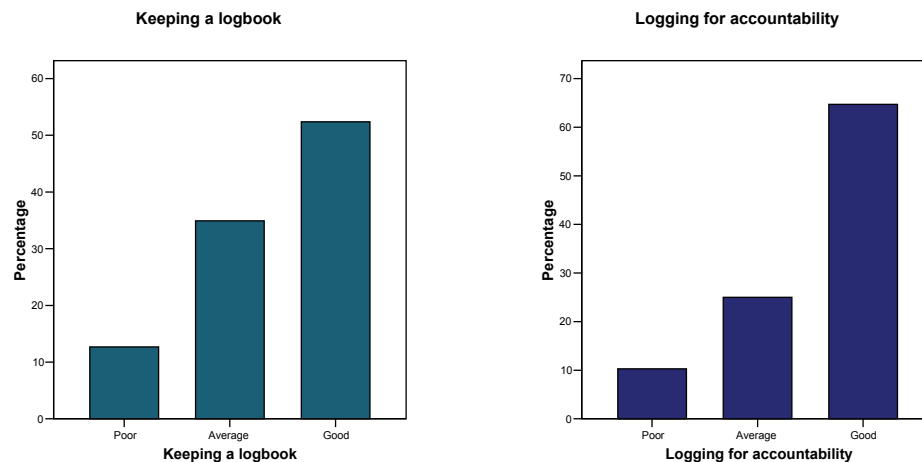


Figure 4. Participant's opinions on variables 'Keeping a logbook' and 'Logging for accountability' in the 1st session (opinions in the 2nd session were not significantly different).

Another source of missing data concerns the communication actions that occurred which were not logged, such as telephone calls and face-to-face communication acts, especially when they took place outside the observers' view. More observers (one observer for each participant) would be necessary to capture everything, which is probably unfeasible, as it will hinder participants' work.

Although this empirical research yields somewhat different results than intended, the content of the communication actions as recorded in the raw database was very revealing for the Gemeente Borsele. The database shows at what time, what type of message was sent to whom, together with keywords reflecting the content of that message (related to unique events in the scenario). When exercises are finished, organizations usually evaluate the exercise on a meta-level; that is, how participants performed, what went well, what went wrong concerning collaboration, etc. Hardly ever do organizations get an insight into the 'content' of the exercise. Our dataset displays what transpired during crisis management, albeit within the boundaries sketched above. It became clear what actually went on in and between the different cells, and how certain events impact parts of the crisis organization. An

example is a phone call from an outsider enquiring about a missing dog. This minor issue was tackled for 20 minutes by two different action centers – relatively long with respect to the duration of the entire exercise. This is visualized in Figure 5. Shown in this picture are the action centers communicating with each other about the missing dog based on our database (OEF-burger is person from exercise control; CRIB and IBW are 2 action centers). As no log exists of any feedback from CRIB towards the OEF-burger it is difficult to establish whether CRIB responded at all – this is an example of the complexity of our analysis.

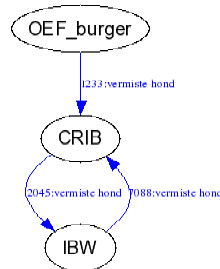


Figure 5. Communication flow regarding the ‘missing dog’ event.

Learning effects and fatigue are two factors contributing to the lack of effect between the two sessions; this is due to the set-up of the exercise. It proved difficult to compare the two sessions as if they were separate, as was initially conceived by the DECIS lab (two separate exercises). Together with the failure to properly introduce the standard message template in between the two sessions, the success of this intervention cannot be properly quantitatively assessed.

Data Analysis: Qualitative Analysis

Questionnaires were not answered by all the participants in the exercise, and quite a few were only partially answered. As mentioned before, this is due to the fact that a number of participants found it very disturbing to be interrupted in their role and some plainly refused to take time to answer the questions. The analysis of the propositions yields trends which are relevant to our research and facilitates discussing the data with the Gemeente Borsele.

Regarding the first section of both questionnaires in which the participants were asked to score 35 propositions, there was no significant difference found between the two sessions, as depicted in Figure 6. In this figure, the mean scores by all respondents for the propositions in each of the categories are shown (see section Methodolgy, measuring qualitatively). On all seven aspects people scored more or less ‘average’ (i.e., 5 points). The questions explicitly asking for a comparison between the two sessions yielded yet again no significant difference. Despite the lack of explicit improvement, one can conclude that the standard message template did not actually make things worse.

Participants’ remarks on the standard message template, however, were mostly negative. They perceived the template as too cumbersome, difficult or unclear to fill in. These types of remarks are attributed to the fact that the template was not properly introduced and the implied unfamiliarity of the participants with working with this template. We still have the impression that the standard message template could be an improvement; this is corroborated by positive statements about the form: “New template is easy to use; it can make the routing insightful; good that a uniform template will be introduced”.

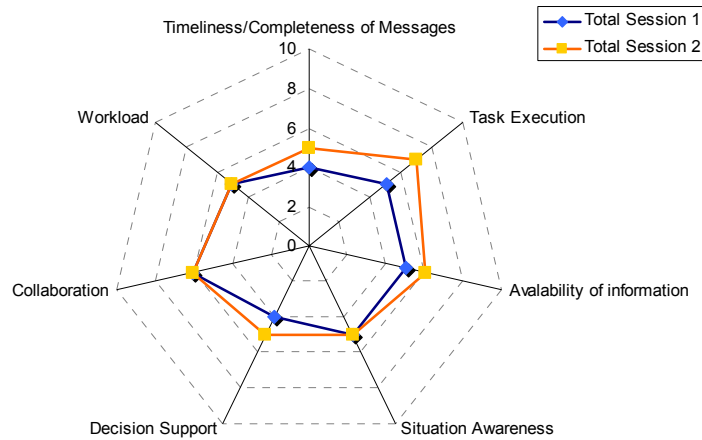


Figure 6. Aggregated scores on propositions from the 7 categories after the two sessions.

Another issue that emerged from the questionnaires was that in different action centers participants voiced their wish to know what other participants in the crisis organization were doing, what they were dealing with, and how the crisis was evolving. In other words they expressed the need for more ‘organization awareness’ as well as situation awareness. In fact it turns out that at least two action centers were involved in the same activity at the same time (locating the bodies of 10 deceased inhabitants). Lack of situation awareness is exemplified in Figures 7 and 8. Visualized here is that situation reports from two sources, the municipal situation reports (Figure 7) and Regional Operational Team reports (ROT) (Figure 8), only travel between the Municipal Directorate (BT), sometimes via Messages Center (BC), and the exercise control (OEF_politie, OEF_PCC and OEF_ROT) outside of the municipality. Action Centers receive this kind of information only through action center heads, who receive this information – if they do – from the Management Team. Of course, not every one needs to know all the details about the entire crisis, but people within action centers are so busy solving their ‘own’ problems, that they loose track of the crisis itself, and would like to have more awareness.

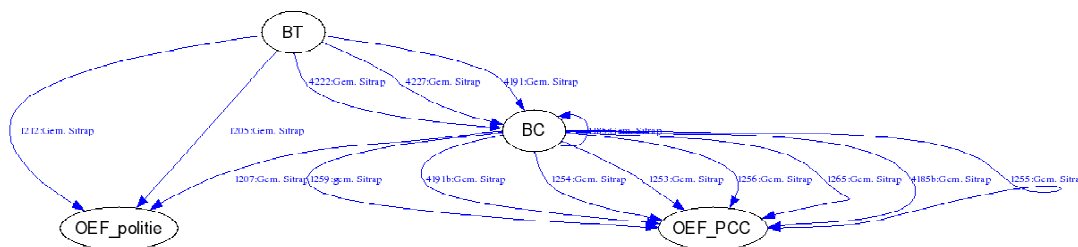


Figure 7. Flow of the municipal situation reports through the crisis organization.

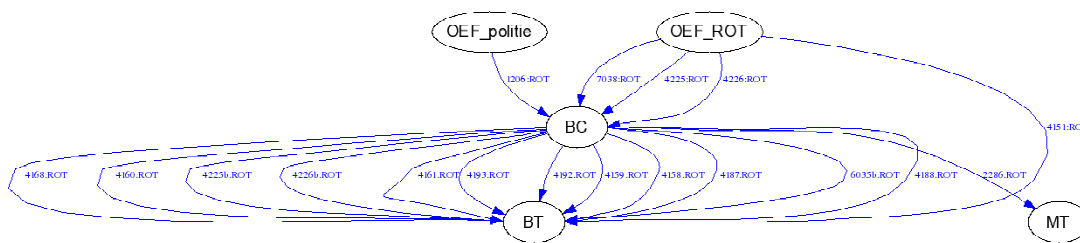


Figure 8. Flow of the regional operational team situation reports through the crisis organization.

DISCUSSION/LESSONS LEARNED

DECIS Lab and Gemeente Borsele have jointly conducted empirical research in the context of a crisis management exercise for Gemeente Borsele. The major objectives of DECIS Lab (collect crisis data, acquire domain knowledge, discover feasibility) and Gemeente Borsele (improve internal communication, and involve entire internal crisis management organization) were mostly achieved. The methodology and results have been described above. Critical aspects regarding this empirical research, some of which are fundamental to empirical research, include:

- The improvement in internal communication was not as drastic as was hoped for; the introduction of the standard message template was not detrimental either. To ascertain the implications of the standard message template, another experiment is needed after proper introduction of the template.
- Pragmatic constraints on empirical data collection: some data cannot be collected at all, other data can be collected and is incomplete, and some data can be collected and is guaranteed to be complete. This greatly affects the possibilities for analysis including the validation of hypotheses.
- People involved in crisis management do not react favorable to any interruption, including the introduction of a standard message template. Ergo the combination of measuring two conditions (without and with the template) in one exercise did not yield as crisp data as desired.
- Structured measurements and analysis already provides real benefits for practitioners, as additional insight can be given. Content-based analysis of the (captured) communications during the exercise enables a better understanding of the nature of interaction within Gemeente Borsele.

On the basis of these experiences with empirical research, four overall lessons-learned are formulated:

- Do not underestimate the importance of researchers being present in the conception phase of the scenario that is to be played. The scenario is interdependent on measurements and experimental objectives. Scientific research designs can not always be realized in a practical crisis management context in which economical, logistical, political and motivational factors play a role.
- To choose the best directions for improvements and solutions, researchers need to investigate current working practices of those affected by these improvements and solutions. Explorative investigations are a prerequisite for establishing measurement criteria and possibilities for data collection.
- Although everything was done in this experimental research (naturalistic experiment) to ensure the validity of the data, the usability of the acquired data for specific purposes cannot easily be controlled, and needs to be taken into account during the analyses.
- Conducting grounded research during an actual crisis management exercise is challenging for more academic oriented researchers and imposes constraints on the data that can be collected. If too-detailed data is to be collected, a higher observer-to-participant ratio is needed, with the added possibility that participants become frustrated and irritated by too-detailed observations of their work.

The experiences with this empirical research already show tangible benefits for both researchers and practitioners. The involved researchers from DECIS Lab have become acquainted with important crisis management aspects, and have become aware of real work-practices, needs and desires. The involved practitioners, especially those involved in setting up the exercise, enacting the scenario as participants, and subsequent evaluation, have gained insight on their own organization, as well as become inspired about possible future developments [4]. DECIS Lab and Gemeente Borsele both aim to continue empirical research to further their own, and their joint, interest in crisis management.

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