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Codifying a crisis: Progressing from information sharing to distributed decision-making

Willem Treurniet[1] | **Jeroen Wolbers**[2]

[1]IFV, Arnhem, The Netherlands

[2]Crisis Research Center, Institute of Security and Global Affairs, Leiden University, The Hague, The Netherlands

Correspondence
Willem Treurniet, IFV, Arnhem, The Netherlands.
Email: willem.treurniet@ifv.nl

Abstract

A key challenge in crisis management is maintaining an adequate information position to support coherent decision-making between a range of actors. Such distributed decision-making is often supported by a common operational picture that not only conveys factual information but also attempts to codify a dynamic and vibrant crisis management process. In this paper, we explain why it is so difficult to move from information sharing towards support for distributed decision-making. We argue that two key processes need to be considered: supporting both the translation of meaning and the transformation of interests between those on the front line and those in the remote response network. Our analysis compares the information-sharing processes in three large-scale emergency response operations in the Netherlands. Results indicate that on several occasions the collaborative decision-making process was hampered because actors limited themselves to factual information exchange. The decision-making process only succeeds when actors take steps to resolve their varying interpretations and interests. This insight offers important lessons for improving information management doctrines and for supporting distributed decision-making processes.

KEYWORDS

command and control, common operational picture, crisis management, decision-making, information sharing

1 | INTRODUCTION

A recurring challenge in crisis management is how to develop an adequate information position (Boin, 't Hart, Stern, & Sundelius, 2005). Gathering and sharing up-to-date information about the crisis is needed to develop and maintain shared awareness of the situation (Klein, Wiggins, & Dominguez, 2010). It also ensures that those involved stay informed about how the response organization is progressing (Deverell, Alvinius, & Hede, 2019; Treurniet, van Buul-Besseling, & Wolbers, 2012), and enables them to develop options regarding how to intervene (Pfaff et al., 2013). Developing an adequate and shared information position requires a collaborative effort by multiple response organizations. Response organizations need to address operational, tactical and strategic issues simultaneously in a rapidly changing environment (Owen, Brooks, Bearman, & Curnin, 2016), which often leads to ambiguity and discontinuity (Wolbers, Boersma, & Groenewegen, 2018).

In the language of crisis managers, this means using a common operational picture to tackle the perceived ambiguity and enable a shared overview of the crisis and the progress of the response operation to be developed (Comfort, Dunn, Johnson, Skertich, & Zagorecki, 2004; Copeland, 2008; Endsley, 1995).

Many technological solutions have been suggested for how to create and maintain a common operational picture, often stressing the importance of collecting and fusing data (Looney, 2001) or of synchronizing and distributing information (Copeland, 2008; DeMarco, 2016). Although there are exceptions (Uhr, 2009), these technical solutions are generally considered to improve the speed and quality of the collaborative decision-making process (Comfort, 2007). Accordingly, information management has predominantly been approached from a warehousing logic, which reveals the assumption that it is possible to collect and store all the relevant information, develop a complete overview of events and specify what actions need to be taken and by whom (Copeland, 2008; DeMarco, 2016; FEMA, 2014; Leedom, 2003). Current studies seriously question this assumption (Wolbers & Boersma, 2013), as it prevents any substantial progress being made on developing a more nuanced information-sharing doctrine (Tatham, Spens, & Kovacs, 2017; Wolbers & Boersma, 2019).

Attempts to compile a complete factual overview during a crisis generally fail because of an important trade-off in information gathering, which is conceptualized as the "variable disjunction of information" (Turner, 1976). By this expression, Turner (1976) means that each actor has access to a slightly different set of information, while the amount of information that can be combined and processed with available resources is less than the amount of information needed to capture the complexity of the situation. This classic trade-off implies that during a crisis no actor is able to attain a perfect information position, because the cost of obtaining a new piece of information has to be balanced against the cost of obtaining an alternative piece. Paradoxically, this means that, in a rapidly changing crisis situation, putting too much effort in constructing a complete overview will eventually result in the information position becoming outdated, because the situation will have already changed significantly by the time the overview is complete. Also, since all the actors collect information to support their own decision-making process at the operational, tactical or strategic level, different perspectives of the crisis situation are likely to develop.

While the promise of many information-sharing doctrines is to support the decision-making processes on the front line, the tactical, and the strategic level, decision-making processes at each of these levels have a quite different logic, and thus different information requirements. Years of research into front-line command highlight that commanders rely on recognition-primed decision-making to connect cues and information to well-known scripts that they have developed from previous experience (Barton & Sutcliffe, 2009; Klein, Calderwood, & Clinton-Cirocco, 1986). This allows them to make quick decisions in environments that involve a high level of risk and complexity. In contrast, strategic-level decision makers use information to support sense-making processes over a longer time period, engage in meaning-making to frame societal impact, and use information to claim or redirect accountability (Boin et al.., 2005). These differences mean that it is highly challenging for a single information-sharing platform to seamlessly connect the front line and the remote response network. The on-scene dynamics and the uncertainties involved render it virtually impossible to convey an up-to-date situational picture that addresses all the aspects that are relevant to those operating remotely at the tactical and strategic levels of the response organization (Bosomworth, Owen, & Curnin, 2017). Likewise, it is very difficult to express broader tactical and strategic perspectives on the situation in a way that is meaningful and manageable at the operational level (Bye et al., 2019; Curnin & Owen, 2013).

Accordingly, we need more insight into how information is translated and transformed as it moves between the front line and the remote response network at the tactical and strategic level. Against this background we ask the research question: *how does information sharing in a crisis management operation contribute to collaborative decision-making between the front line and the remote response network?* To answer this question, we studied the information-sharing and collaborative decision-making processes during three large-scale emergency response operations that took place in the same region in the Netherlands.

2 | THEORETICAL FRAMEWORK

It is well known that a crisis management operation consists of different collaborative decision-making processes taking place at the operational, tactical and strategic level (Boin et al., 2005; Curnin & Owen, 2013; Owen et al., 2016). Chen, Sharman, Rao, and Upadhyaya (2008) argue that collaborative decision-making processes in response operations can be conceptualized as a number of nested decision-making cycles, which we refer to as the *front line* and *remote response network*. A range of studies describe a tension between the front line and the tactical/strategic level (Bosomworth et al., 2017; Curnin & Owen, 2013; Owen et al., 2016). Front-line cycles of coordination that support firefighting, acute medical care or police operations involve actions that need an immediate reaction and do not allow for lengthy deliberation. Rimstad and Sollid (2015) use the 2011 Norway terrorist attack to show that front-line operations are characterized by rapid critical decisions, made primarily on the basis of pattern recognition (Cohen-Hatton, Butler, & Honey, 2015; Groenendaal & Helsloot, 2018; Klein, 1993; Meso, Troutt, & Rudnicka, 2002). These front-line processes can be highly chaotic and unpredictable, and may sometimes even be incomprehensible to actors operating at a distance (Barton, Sutcliffe, Vogus, & DeWitt, 2015; Boehm, 2018; Curnin, Brooks, & Owen, 2020; Nja & Rake, 2009).

The remote response network typically seeks to address the broader, long-term impact of the crisis by focusing on the implications for various stakeholders, resource allocation, and community expectations (Curnin, Owen, Paton, & Brooks, 2015). Those at the strategic level—generally as part of the remote response network—focus on meaning-making, which entails offering the broader community a frame through which the crisis situation can be understood (Boin et al., 2005; You & Ju, 2019). Boin, Brown, and Richardson (2019) show that in the response to Hurricane Katrina different organizations and officials communicated different frames, but most of these frames had hardly any connection to how the situation was experienced by those at the front line.

As such, the front line and the remote response network can be two "worlds in themselves" (Njå & Rake, 2008). While front-line processes are driven by "knowledge by acquaintance," the remote response network is driven by "knowledge by description" (Baron & Misovich, 1999). This is an important difference, and means that it is difficult for the organization as a whole to be sensitive to the lived experience and concrete situational details to which those at the front line have access (Barton et al., 2015). Only as time goes on, and more room becomes available for longer deliberation and for the facts to be validated, can those at the tactical and strategic level use their more overarching risk assessments to provide more active guidance to the front-line operations (Rimstad & Sollid, 2015; Scholtens, 2008). However, actively steering front-line operations too soon generally results in the strategic-level decision makers being accused on engaging in micromanagement.

Collaborative decision-making in emergency response is thus a multifaceted and nested phenomenon. It is multifaceted in the sense that it requires knowledge-intensive transboundary collaboration between organizations with differing knowledge bases and expertise. It is nested in the sense that it typically consists of a number of interconnected decision-making cycles, differing in their level of abstraction and the time pressure involved. The multifaceted and nested nature of the collaborative decision-making processes feeds into the state of variable disjunction of information among the organizations contributing to the response (Turner, 1976).

The common operational picture, as an information-sharing platform, plays a key role in connecting the perspectives of the different teams across organizational boundaries (Ansell, Boin, & Keller, 2010), providing an up-to-date representation of the status of the emergency situation and the actions taken in response. Underlying the discussion of the common operational picture as an information-sharing platform is the notion of developing a shared situational awareness (O'Brien, Read, & Salmon, 2020). The debate on this subject flourished in the 1990s and early 2000s, with a range of studies being conducted in aviation and in the naval and military domain (Endsley, 1995; Hutchins, 1995; Salmon et al., 2008; Sarter & Woods, 1991; Taylor & Selcon, 1990). These studies describe situational awareness as being acquired through cognitive processes that integrate knowledge derived from recurrent situation assessment (Salmon et al., 2008). The debate cumulated in a range of cognitive process models that describe how information is processed and evaluated to support decision-making (Bedny & Meister, 1999; Endsley, 1995; Smith & Hancock, 1995).

While the debate on shared situational awareness offered a predominantly cognitive approach to information sharing, later studies showed that information management should be broadened out into a cyclic and collaborative sense-making process that feeds into the development of shared situational awareness (Klein et al., 2010). During the process of information sharing, it is important to leave room for different sense-making accounts (Wolbers & Boersma, 2013). For different teams and different organizations, different aspects of the situation are relevant. The common operational picture should be able to reflect these differences, and a continuous process of collaborative framing, questioning and reframing should help to reconcile the differing perspectives to arrive at a more consistent, less equivocal view of the situation (Klein et al., 2010). This combination of collaborative sense-making and shared situational awareness makes collaboration on the basis of a common operational picture both complex and effective.

As the common operational picture is intended to support the transboundary collaboration between the front line and remote response network (Comfort et al., 2004), its supporting role is more problematic than is often suggested in the literature. The information-sharing dilemmas that are experienced in response operations are often more complex and nuanced than can be captured in factual terminology. As such, crisis information management also involves more reflective, knowledge-intensive processes, such as meaning-making, prioritization, future scenario development and considerations of the rationale of the response. However, we know relatively little about the processes of sharing these more abstract levels of information that play a part in supporting collaborative decision-making (Wolbers & Boersma, 2013).

Carlile (2002, 2004) conducted relevant research on information sharing in distributed organizations. He distinguishes three levels on which information can be shared: the syntactic level of *factual information*, the semantic level of *interpretations* and the pragmatic level of *implications* that interpreted facts may have for the interests of other actors involved. Likewise, crisis management scholars have pointed out that *translation* of the inherent meaning of terms is generally needed, because meanings and implications of the information transferred must be exchanged and coordinated as well (Kalkman, Kerstholt, & Roelofs, 2018; Luokkala, Nikander, Korpi, Virrantaus, & Torkki, 2017; Merkus et al., 2017; Van de Walle, Brugghemans, & Comes, 2016; Wolbers & Boersma, 2013). Others have argued that interests have to be negotiated between collaboration partners (Ansell et al., 2010; Wimelius & Engberg, 2015), which means that the contextual meaning of information must be *transformed*. In this paper, we take a closer look at information sharing by analysing how using these various levels of information sharing contributes to collaborative decision-making by the front line and the remote response network.

3 | METHOD

We conducted a detailed qualitative analysis of how information sharing supports collaborative decision-making by differentiating between different levels of information sharing. We analysed three real-life emergency management operations: a gas explosion in an apartment building in 2010, a shooting in a shopping mall in 2011 and the collapse of two cranes being used to hoist a bridge deck in 2015. For each operation, we examined how the information provided in a common operational picture was used to address key collaborative decision-making challenges. The analysis was complemented by semi-structured interviews with operational officers involved in one or more of the operations. All three cases were sudden-onset crises, the tactical lead resided with the same commander, and they took place in the

same municipality: Alphen aan den Rijn in the Dutch safety region of Hollands-Midden. Evaluation reports and media accounts show that the response to all three incidents was successful in several senses (McConnell, 2011). First, it followed pre-anticipated and appropriate processes and the decisions taken had the effect of minimizing damage and loss of life. Second, those decisions ensured that political goals were achieved without attracting any substantial opposition. Furthermore, the three incidents occurred during a period in which a specific information management doctrine, netcentric operations (Alberts, Garstka, & Stein, 1999), was being implemented in the Netherlands. In netcentric operations, each participating team is responsible for maintaining an up-to-date representation of the situation, reflecting the professional perspective of that team and for sharing this representation with other teams (de Ven, Van Rijk, Essens, & Frinking, 2008). In addition, a new role was introduced into the crisis management structure: information managers watched over the coherence between the operational, tactical and strategic command level.

The response to regional-level incidents, like the three we analysed, is coordinated as follows (Scholtens, 2008). The front-line operation is coordinated by an on-scene multidisciplinary command team in which all the disciplines working directly at the incident location are represented. This on-scene command team is led by a field commander, who is supported by an information manager. This information manager is responsible for maintaining an up-to-date operational picture and sharing it with the rest of the emergency response network. A tactical command team is also established, based well away from the incident location. This remote team is responsible for supporting the on-scene operation and for dealing with the broader effects of the incidents. These include both physical effects, such as the spread of smoke or toxic gases, and psychosocial effects, such as social unrest and turbulence in social media. This tactical command team is led by a tactical commander, who is supported by an information management section. The information manager leading this section is responsible for maintaining an up-to-date tactical picture and for the coherence of the common operational picture as a whole. If the incident involves issues that require substantial coordination at the municipal level, a strategic coordination team is established. This team, which also meets somewhere remote from the incident location, is led by the mayor of the municipality or by the chairman of the safety region, usually the mayor of the largest city in the safety region.

We collected our data from two different information-sharing platforms: the information system of the emergence response centre (GMS), and the nationwide crisis management system (LCMS). The GMS registrations are basically tables in which each row contains one entry extracted from the information system. An entry of this type includes a date, a time, the name of the dispatcher and a text message. Data from the LCMS reflect a dedicated view for each of the teams operating at the different levels of command. Each view contains one or more textual fields. For our qualitative analysis, we used a chronological list of field mutations extracted from the LCMS. Each field mutation consists of an identifier for the view, an identifier for the field, a date/time group, an identifier for the person who has modified the field and the contents of the field.

For each of the cases, the contents of the GMS registration and the registration exported from LCMS were integrated into one table. In this process, the text messages from the GMS registration were copied exactly. To incorporate the field modifications from the LCMS registration, some manual processing was needed. The marked insertions and deletions had to be converted to a textual description capturing the essence of the modification.

We assessed the three cases from a process perspective (Langley, 1999). We applied a *narrative strategy* as a preliminary step to prepare a chronology for subsequent analysis. This strategy involves constructing a detailed story from the raw data. Subsequently, we aligned the data to the three levels of information sharing: *factual information*, *interpretations* of the factual information and *implications* that the interpreted facts may have for the interests of other actors involved. At the interpretations level, we broke the data down into a series of multidisciplinary decision-making themes that were discernible on the information-sharing platforms. At the implications level, we examined the choices that needed to be made at the strategic level and those that involved deep uncertainty (Walker, Lempert, & Kwakkel, 2013), where conflicting interests needed to be weighed against each other. By taking this processual approach, which involves contextualization of the decisions made, we account for possible hindsight bias, which can occur when causal reasoning alone is used to explain crisis decision-making (Schakel & Wolbers, 2019).

To reconstruct the information-sharing process over time in each of the three cases, we engaged in "recursive cycling among the case data" (Eisenhardt & Graebner, 2007, p. 25). This entailed going back and forth between the empirical data, the templates we used for categorization, and the logic of the narrative. Through this process, we derived a coding structure, consisting of a number of themes with underlying concepts (Gioia, Corley, & Hamilton, 2013). Each of the themes expresses a key collaborative decision-making topic that could be discerned as a thread running throughout the emergency management operation. This coding structure allowed us to visualize the processes used to reach different levels of information sharing and to relate them to key collaborative decision-making topics (see Appendix).

We validated our initial analysis by conducting a member check (Schwartz-Shea & Yanow, 2009) using reflective interviews with six officers involved in one or more of the cases. One of them was the tactical leader of the emergency response in all three cases. Four of them were responsible at the operational level for a significant part of the decision-making in one or more of the three cases. One was involved as information manager in one of the cases. The interviews took place in 2016 and 2018 and lasted two to four hours. The visual reconstructions of the information-sharing process over time formed the main input for our conversations with the officers. This visual reconstruction helped them to bridge the gaps between the time when the incidents occurred and the point at which the reflective interviews took place. The officers reflected extensively upon the cases, and identified what they had experienced as the toughest episodes and collaborative decision-making issues. They also reviewed our reconstruction of how the information-sharing process unfolded and reflected on what role the different levels of information sharing had played in addressing the

decision-making challenges. Whenever necessary, the underlying data was referred to during the sessions. We transcribed and analysed these interviews in order to build a richer picture of what had occurred and to deconstruct the key challenges in the collaborative decision-making processes that we had identified through our document analysis. This approach gave us a richer understanding of the collaborative decision-making process, which we will now describe in detail.

4 | FINDINGS

The three incidents featured as cases in our study occurred in the municipality of Alphen aan den Rijn, the Netherlands, on 6 December 2010, 9 April 2011, and 8 August 2015, respectively. On 6 December 2010, there was a gas explosion in an apartment building. As a result of the subsequent fire and the structural damage caused by the explosion, the apartment building had to be evacuated. On 9 April 2011, there was a serious shooting incident in a mall. Seven people, including the perpetrator, lost their lives and seventeen were wounded. On 8 August 2015, two large cranes toppled over into a residential area while a new bridge deck was being hoisted into place. A number of houses and shops were damaged or destroyed.

For each of the cases, we provide a short description, and we then sketch out a particular collaborative decision-making issue faced by the crisis managers. We describe the collaborative decision-making dilemma from the perspective of the front line and the remote response network. We also describe how the level of information sharing throughout the emergence response organization developed over time while this issue was being dealt with and how it was concluded.

4.1 | Arranging emergency accommodation after a gas explosion in a residential flat

Monday 6 December 2010 was a mostly cloudy day in the Netherlands, with temperatures close to freezing. At 1.01 p.m., the emergency room of the Hollands-Midden safety region received information about an explosion in a six-storey apartment building in Alphen aan den Rijn (*Explosion on the sixth floor. Windows have been blown out*.). After the explosion, a fire broke out in a number of the apartments. As a result, and because the explosion had caused structural damage to the apartment building, the building was evacuated.

The key decision-making topics in this emergency response operation are listed in the Appendix. One of the key topics in which information sharing played an essential role in supporting the distributed decision-making was arranging temporary accommodation for the inhabitants of the apartments. In doing so, they faced various difficulties to codify the emergent nature of this process. Figure 1 provides a reconstructed timeline of the accommodation process.

Before the command teams were established, the units on the street realized that emergency accommodation would need to be arranged. So as to waste no time the staff in the emergency centre began arranging emergency accommodation 29 min after the initial emergency call was received. The on-scene commander said in the interview: *It is not really a very explicit intellectual process. It is more like a strategy of coincidental opportunities. If the first solution solves the problem, that is sufficient. We have other things to do*. The emergency centralists registered in their system details of the front-line initiatives being taken to arrange emergency accommodation. As it is ultimately the responsibility of the municipality to arrange accommodation, the municipality officials were alerted in parallel. Eight minutes later, a separate process was initiated by the municipality, in accordance with its own pre-planned scripts. Another three minutes later, the police initiated a third process. Finally, five minutes after that, the "De Bron" church centre spontaneously opened its doors and started to welcome people who had been affected (*De Bron is already arranging care*).

Three different processes were started in parallel to arrange accommodation. Those involved in these three processes quickly shared factual information about their decisions, but even small delays in information sharing led to coordination problems due to the speed of the action trajectories. The confusion lasted for the next 70 min. By that time, the centralists in the emergency centre were clearly annoyed, as reflected in their use of capitals and exclamation

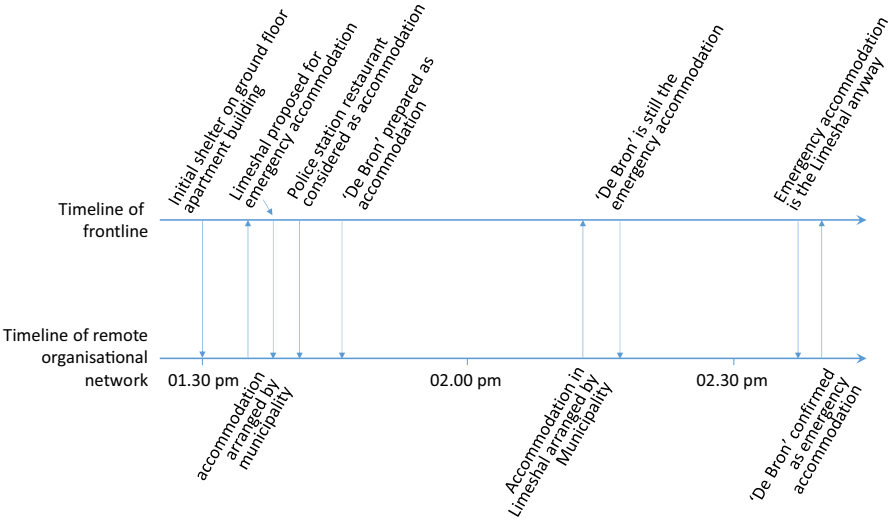

FIGURE 1 Timeline of arranging accommodation

FIGURE 2 Irritation reflected in extract from the emergency centre registration

marks: *EMERGENCY ACCOMMODATION DE BRON!!! SOURCE: REGIONAL OPERATIONAL TEAM* (Figure 2).

The on-scene commander explained in the interview: *Initially, we had arranged accommodation. After scaling up to the tactical level, the tactical team did it all over again, with a different location. So, we decided to move the people to this new location. We thought: oh, did they come up with something else again, you know? Then the tactical team decided: well, all right, let them go back anyway. And the people went back again!*

This case shows that accommodation typically has to be arranged while the incident command structure is still being established. Thus it can often be the case that initiatives are started spontaneously by other groups within the local community, running in parallel with the activities of the emergency responders. While it is important that all the partners involved are informed quickly about initiatives, even short delays can easily lead to conflicting actions and agreements at the network level. Furthermore, in this particular case sharing factual information about the locations was not sufficient, as deliberation over choices and the implications of particular choices could not be easily codified in the common operational picture. Hence, having a common operational picture does not guarantee that that the implications of particular decisions will be considered by different actors in the response network.

4.2 | Bomb threat after a mall shooting

On Saturday 9 April 2011, at 12.09 p.m., the Hollands-Midden safety region received an emergency call: *Shooting in the De Ridderhof mall!* De Ridderhof is in the municipality of Alphen aan den Rijn. The call was soon followed by reports of injuries. Police units and paramedics rushed to the mall. After a few minutes the shooting was over. At 12.19 p.m., it was reported that the gunman had committed suicide. In the shooting, seven people, including the perpetrator, lost their lives and seventeen were seriously injured. At 2.10 p.m., it was confirmed that there had been only one perpetrator. Around the same time, an on-site command team was established. This team took charge of operational coordination of response activities at the scene, including attending to the wounded, identifying those who had been killed, and undertaking forensic investigation.

The main decision-making topics the emergency response organization had to deal with are listed in the Appendix. As part of the safety and security challenge in this incident, a particular episode in the information-sharing process played a key role in supporting collaborative decision-making. The central question in this episode was the following: how to deal with and codify the bomb threat posed against the De Ridderhof mall?

At 1.55 p.m., the gunman's car was found with an envelope on the passenger seat. After the car had been carefully opened by a bomb squad, the envelope was found to contain a bomb threat to a number of shopping malls in Alphen aan den Rijn. At that time, a forensic team had started its investigation inside De Ridderhof, although it was not immediately clear whether the bomb threat included De Ridderhof as well. As a precaution, the front-line commander immediately decided to stop the forensic investigation and evacuate De Ridderhof. Figure 3 depicts the information exchange between the front-line commander and the remote response network. The decision of the front-line commander to evacuate De Ridderhof was communicated via the common operational picture and is indicated in the figure by bold arrows (implications level). In the remote response network, several teams at the tactical and strategic level started a two-and-a-half-hour deliberation about which malls should be evacuated. Factual information about the progress of this deliberation was shared through the common operational picture. The outcome was that it was decided there was no bomb threat to De Ridderhof, so clearance was given to proceed with the forensic investigation.

The front-line commander at De Ridderhof reflected on this: *I asked the question: "Are we safe here, yes or no?" This question was ultimately even dealt with in the strategic team. Finally they said: "Yes, De Ridderhof is safe." By that time, I was, like, what is happening on the street, what is happening in the tactical team, what is happening in the strategic team? We had been taking measures even before they talked about it and decided on it. […] Now the strategic team decided De Ridderhof is not at risk. […] This made the forensic investigation team ask: "Why is it safe now? Who decides on that? Does the strategic team decide that it is safe?"* In other words, implications-level information from the remote response network did not convince the front-line commander and the teams operating there that it was safe to work in De Ridderhof.

The forensic investigators would not resume their work until an explosives scout had determined that there was no sign of an explosive device in De Ridderhof. While the front-line commander was saying that an explosives scout needed to confirm it was safe in order for work to resume, the remote response network was still stating that searching for explosives in De Ridderhof was *not* necessary (Figure 3). This stand-off tells us that even if information about the uncertainty over the bomb threat is shared, the lived experience of uncertainty is not addressed by simply sharing factual information. Safety issues and the urgent need to carry out risk assessments are very much dependent on the perspective of the beholder. In this case, the front line and the remote response networks seemed to be operating in two entirely different worlds.

4.3 | Instability of pontoons

On Monday 8 August 2015, at 4.09 p.m., the emergency centre servicing the area of the Hollands-Midden safety region received the following call: *a crane has fallen down on shops and houses*. The

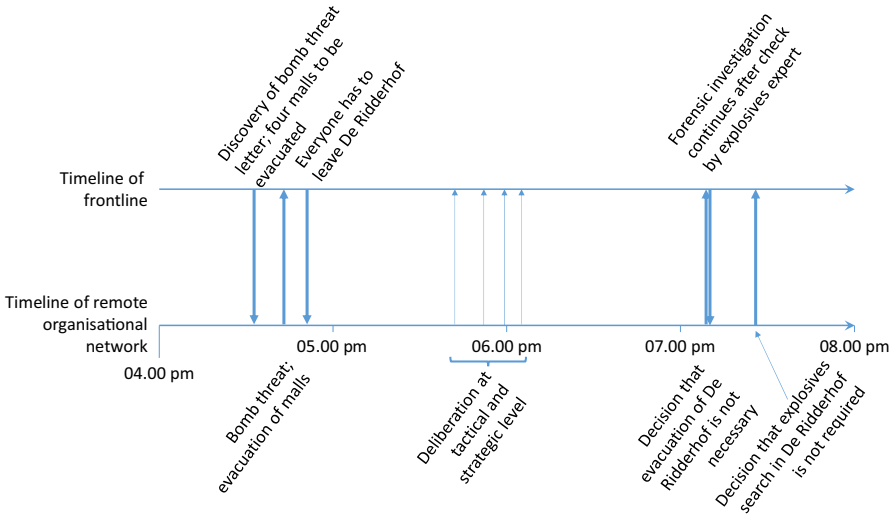

FIGURE 3 Information exchange about whether or not to evacuate De Ridderhof

call came from a citizen in the municipality of Alphen aan den Rijn. Two heavy cranes were being used to instal a new bridge deck across the river Oude Rijn. The cranes were positioned on pontoons in the Oude Rijn. At a critical moment in the hoist operation, the combination of the cranes and the pontoons became unstable. Both the cranes and the bridge deck toppled over, destroying two shops and two houses on the eastern bank of the Oude Rijn. A number of other buildings were also damaged. Given the enormous havoc, it was expected that there could very well be up to twenty victims. Miraculously, the only casualty turned out to be a dog.

The key decision-making topics the emergency response organization had to deal with are listed in the Appendix. Whether or not the heap of rubble was sufficiently stable, despite of the apparent movement of the pontoons, was one of the key issues in codifying the information-sharing process to support distributed decision-making.

Figure 4 depicts the information exchange between the front line and the remote response network relating to evacuation and the release of addresses during the first 24 hr of the response operation. During the first few hours, the front-line commanders struggled to assess the stability of the heap of rubble. During that period, the front-line commanders communicated factual information about the four addresses that had been directly hit by the fallen cranes, as well as the 35 other properties that were evacuated for safety reasons. In Figure 4, this factual information exchange is shown by thin arrows. The front-line commander recalled that he received a phone call around 10.00 p.m. from the tactical-level commander, who asked why it was not possible to declare some of the evacuated addresses safe. The front-line commander replied: *We just do not know. Have some confidence that we deploy people to investigate the situation, but we do not know yet and we cannot be faster than we are now.* This conversation between the front-line commander and the tactical commander—indicated in Figure 4 by the first bold arrow—can be characterized as an information exchange at the implications level: the front-line officer asked for attention to be paid to the safety of the people being evacuated and the tactical officer sought to minimize the disruption to daily life.

Later in the evening, some of the addresses were declared safe and the residents were able to return to their homes. By noon the next day, 28 of the properties initially evacuated had been declared safe. At that point, the front-line commander who had been working at the scene the previous evening was called back to the front line. He found a situation in which the uncertainty over the mechanical stability of the heap of rubble was actually no less than it had been

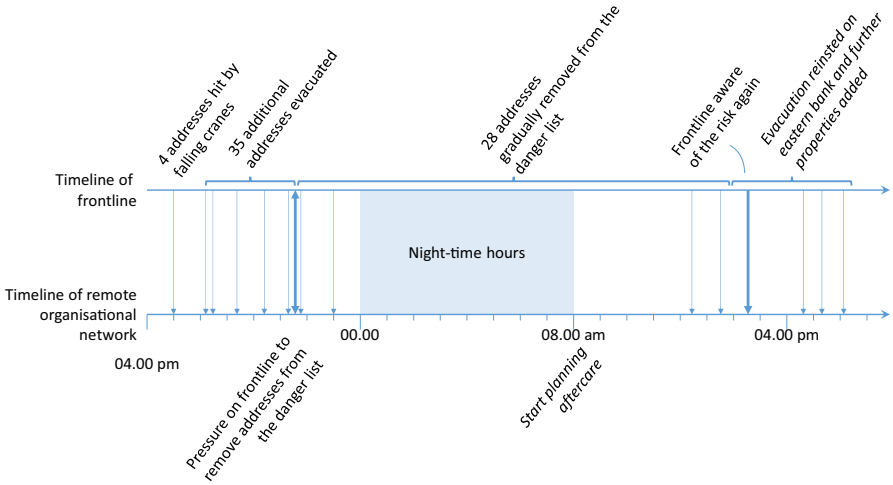

FIGURE 4 Information exchange on the evacuation of addresses and the removal of addresses from the danger list

the evening before, even though a substantial number of houses had been declared safe in the meantime. He immediately decided to re-evacuate the inhabitants of those houses. In an interview he recalled: *… really, my basic thought was: how is that possible? That is not possible! It is still unstable! It is still moving! The stability has not been calculated at all… How could they do this?* Another front-line fire officer recounted in an interview that *The quay joist hung on just four screws – tiles [of the pavement] had come upwards*. The first re-evacuation was registered in the common operational picture as: *CHANGE: <address > is being evacuated because of instability of pontoon*. In Figure 4, this information exchange is indicated by the second bold arrow. The first part of the sentence provides factual information with respect to evacuation of an address. The second part of the sentence conveys implications-level information about the reason for the evacuation.

After the initial phase of hectic activity, the emergence response organization was faced with the issue of how to deal with an apparently unstable heap of rubble. A delicate assessment had to be made as to whether to accept the risk of further collapse or whether to continue evacuating houses. The front-line commander reflected on this dilemma: *I don't argue that the administrative reality is a reality; it is very true! Weighing up whether an area has to be evacuated or not… I understand it very well! The thing is, perspectives have to be brought together. Sharing information in LCMS, in information systems and in netcentric collaboration environments is not only about factual information. That is where netcentric collaboration fails. It is about common intention, common interests, however you want to look at it. […] Here I was bothered by the tactical team because I had been saying, you know, don't ask me to speed up, don't push me to work harder and better, because I'm really doing as much as I can. Help me above all by asking where you can support me, what [our information] really means, and what interpretation can be attached to it!* This reflection underlines the differences in interpretations—in terms of implications—between those at the front line and those in the remote response network. The common operational picture did not provide sufficient support to those who had to decide between ensuring safety and minimizing disruption to daily life. It seemed impossible to codify the complexity and uncertainty of the situation in the common operational picture, and thereby span the boundary between the front line and the remote response network.

4.4 | Analysis

Our analysis indicates that information codified in the common operational picture is mostly *factual information* about the developing situation. By factual information, we mean the characteristics of the incident and the actions taken by each of the various response organizations. In general, sharing factual information provides a solid basis for collaborative decision-making. However, in each of the cases we analysed crisis managers faced periods of confusion in which information sharing at the factual level was not sufficient to overcome the collaborative decision-making challenges. It required information exchange at the level of interpretation and/or at the level of implications to provide direction and to bridge the semantic or pragmatic boundary between the front line and the remote response network. Only after that boundary had been bridged could information exchange at the factual level again support the collaborative decision-making process.

If we zoom in on the information exchange between the front line and the remote response network, we see that not all front-line information can be codified in time to be of use. On the front line, rapid decision-making takes place on the basis of pattern recognition, which is hard to convey. The quick decisions to evacuate immediately after the cranes had collapsed are examples of this. These decisions were based on an overall impression of the local situation, including the structure of the heap of rubble, the layout and nature of the built-up area, the apparent tension in the cables of the cranes and the fact that they were attached to the quay. On several occasions, the dynamics of the situation and the uncertainty made it difficult to codify the situation in real time. An example of this is the rapid decision to abort the forensic investigation immediately after it became known that a bomb threat might have been issued against De Ridderhof.

In all of our cases, we saw that task differentiation results in the variable disjunction of information, which leads to different sense-making accounts (Turner, 1976). Even if teams find other ways to express and exchange their perspectives, and share their views on what implications their actions may have for their interests, differences in sense-making emerge. In other words, if different actors or teams are taking different actions in different contexts (e.g. on-scene vs. remote), the perceived relevance and meaning of the facts may also differ (Barton et al., 2015). An example of this is the front-line decision not to resume the forensic investigation until after an explosives scout had established that there were no signs of any explosive devices, even though the remote response network had already deemed it to be safe. This also complicates the flow of information, codified in the common operational picture, from the remote response network to the front line. In principle, the perspectives of those at the tactical and strategic level of the emergency response organization—who are typically remote from the location of the incident—provide relevant context for those at the front line. If those in the remote response network do not have a rich and up-to-date view of the situation at the scene and of the dilemmas being faced at the front line, it is difficult for them to make appropriate decisions about what information about the broader context of the incident will be relevant to the front-line responders.

5 | DISCUSSION AND CONCLUSIONS

In this paper, we asked the question: *how does information sharing in a crisis management operation contribute to collaborative decision-making between the front line and the remote response network?* Our qualitative analysis of the collaborative decision-making processes during

three large emergency response operations in the Netherlands has increased our understanding of different levels of information sharing during a crisis. We found that the information codified in a common operational picture to support distributed decision-making was predominantly factual. At the time when the three cases in our study took place, those involved were gaining experience of collaborating on the basis of a new information management doctrine. The tactical officer in charge of all three cases explained that their growing understanding of how to work with this netcentric operations doctrine helped to mitigate the variable disjunction of information and contributed directly to the coherence of the emergency response. In many academic discussions, however, the warehousing philosophy of information sharing, in which factual information is conveyed, has been presented too categorically as an enabler of transboundary decision-making (Cinque, Esposito, Fiorentino, Carrasco, & Matarese, 2015; Copeland, 2008; DeMarco, 2016). Our analysis shows that, in particular, the differences between the decision-making dynamic of the front line and the remote response network cannot be bridged completely by sharing factual information. The information acquired by the front line, as well as the uncertainty inherent in that information, cannot always be codified in time or in sufficient detail to provide the remote response network with input for tactical and strategic-level decision-making (Barton et al., 2015). As a result, especially in dynamic and chaotic circumstances, the front line and the remote response network can easily be operating in two worlds (Rimstad & Sollid, 2015).

A practical implication of our findings is that both the front-line staff and those in the remote response network should be aware of the different levels of information sharing and should be hesitant about relying too quickly or too extensively on sharing factual information via a technical platform. In order to stimulate tactical and strategic sense-making, it may take deliberate acts of sense-giving, sense-demanding and sense-breaking to advance understanding (Vlaar, Fenema, & Tiwari, 2008). Although information-sharing platforms certainly do play a role in reducing the variable disjunction of information at the level of factual information (Turner, 1976), richer forms of information sharing are needed to bridge semantic and pragmatic boundaries. Establishing direct radio links and telephone and video connections might be useful to provide a platform to share concerns that are more implicit, more complex, and that have hitherto been tacit. Indeed, Barton and Sutcliffe (2009) stress the importance of voicing concerns that may emerge in a collaborative effort in order to overcome dysfunctional momentum of the collaborative process.

Our findings complement the work of Wolbers and Boersma (2013), who argue that a common operational picture should be regarded as a trading zone rather than an information warehouse used in the exchange of factual information. While their study focused predominantly on the level of interpretations, we extend this discussion by adding the level of interest into the information-sharing process. Building on the conceptualization of information exchange made by Carlile (2004), our study indicates that, in the trading zone, actors are not only having to negotiate regarding the different meanings but also need to negotiate regarding the different implications that a particular piece of information, and any collaborative decisions taken in response to it, may have for their own functioning or the functioning of others. Particularly in parts of the emergency response organization where there is ample time to gather and transfer information and where careful thought can be given to how information is translated and transformed, the integrative framework proposed by Carlile (2004) for managing information can be readily applied.

A practical implication of this insight is that stagnation in the collaborative decision-making process may be overcome by deliberately shifting the focus to the interpretation or implications level of information exchange. The emergency response organization should be very precise in terms of how it uses terminology. Lack of clarity over terms may be indicative of a misunderstanding between organizations, and time may be required to reach agreement on the interpretation. More complex negotiation of interests is needed at the implications level to develop creative and transboundary problem solving (Leonard-Barton, 1995). The development of multidisciplinary scenarios may be necessary in such cases to provide the insights needed. Overall, the information-sharing infrastructure provides sufficient support for sharing factual information and engaging in rule-based decision-making. However, to support more transboundary collaborative decision-making, which requires more extensive deliberation of dilemmas and insight into the perspectives of other actors, additional methods of information sharing are likely to be required to overcome the semantic and pragmatic boundaries that are in place.

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REFERENCES

Alberts, D. S., Garstka, J. J., & Stein, F. P. (1999). *Network centric warfare: Developing and leveraging information superiority* (2nd ed. (Revised) ed).

Ansell, C., Boin, A., & Keller, A. (2010). Managing transboundary crises: Identifying the building blocks of an effective response system. *Journal of Contingencies and Crisis Management*, *18*(4), 195–207. https://doi.org/10.1111/j.1468-5973.2010.00620.x

Baron, R. M., & Misovich, S. J. (1999). On the relationship between social and cognitive modes of organization. In S. Chaiken, & Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 586–605). New York, NY, US: Guilford Press.

Barton, M. A., & Sutcliffe, K. M. (2009). Overcoming dysfunctional momentum: Organizational safety as a social achievement. *Human Relations*, *62*(9), 1327–1356. https://doi.org/10.1177/0018726709334491

Barton, M. A., Sutcliffe, K. M., Vogus, T. J., & DeWitt, T. (2015). Performing under uncertainty: Contextualized engagement in wildland firefighting. *Journal of Contingencies and Crisis Management*, *23*(2), 74–83. https://doi.org/10.1111/1468-5973.12076

Bedny, G., & Meister, D. (1999). Theory of activity and situation awareness. *International Journal of Cognitive Ergonomics*, *3*(1), 63–72. https://doi.org/10.1207/s15327566ijce0301_5

Boehm, M. (2018). Recalling the performativity of the body in frontline command. *Journal of Contingencies and Crisis Management*, *26*(4), 461–468. https://doi.org/10.1111/1468-5973.12225

Boin, A., Brown, C., & Richardson, J. A. (2019). *Managing Hurricane Katrina: Lessons from a Megacrisis*. Baton Rouge, LA: Louisiana State University Press.

Boin, A., 't Hart, P., Stern, E. K., & Sundelius, B. (2005). *The politics of crisis management: Public leadership under pressure*. Cambridge, UK: Cambridge University Press.

Bosomworth, K., Owen, C., & Curnin, S. (2017). Addressing challenges for future strategic-level emergency management: Reframing, networking, and capacity-building. *Disasters*, *41*(2), 306–323. https://doi.org/10.1111/disa.12196

Bye, R. J., Almklov, P., Antonsen, S., Nyheim, O. M., Aalberg, A. L., & Johnsen, S. O. (2019). The institutional context of crisis. A study of the police response during the 22 July terror attacks in Norway. *Safety Science*, *111*, 67–79. https://doi.org/10.1016/j.ssci.2018.09.011

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455. https://doi.org/10.1287/orsc.13.4.442.2953

Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science*, *15*(5), 555–568. https://doi.org/10.1287/orsc.1040.0094

Chen, R., Sharman, R., Rao, H. R., & Upadhyaya, S. J. (2008). Coordination in emergency response management. *Communications of the ACM*, *51*(5), 66–73. https://doi.org/10.1145/1342327.1342340

Cinque, M., Esposito, C., Fiorentino, M., Carrasco, F. J. P., & Matarese, F. (2015). *A collaboration platform for data sharing among heterogeneous relief organizations for disaster management*. Paper presented at the ISCRAM 2015 Conference, Kristiansand, Norway.

Cohen-Hatton, S. R., Butler, P. C., & Honey, R. C. (2015). An investigation of operational decision making in situ: Incident command in the UK Fire and rescue service. *Human Factors*, *57*(5), 793–804. https://doi.org/10.1177/0018720815578266

Comfort, L. K. (2007). Crisis management in hindsight: Cognition, communication, coordination, and control. *Public Administration Review*, *67*(Suppl. 1), 189–197. https://doi.org/10.1111/j.1540-6210.2007.00827.x

Comfort, L. K., Dunn, M., Johnson, D., Skertich, R., & Zagorecki, A. (2004). Coordination in complex systems: Increasing efficiency in disaster mitigation and response. *International Journal of Emergency Management*, *2*(1–2), 62–80. https://doi.org/10.1504/IJEM.2004.005314

Copeland, J. (2008). *Emergency response: Unity of effort through a common operational picture: ARMY WAR COLL CARLISLE BARRACKS PA*.

Curnin, S., Brooks, B., & Owen, C. (2020). A case study of disaster decision-making in the presence of anomalies and absence of recognition. *Journal of Contingencies and Crisis Management*, *28*(2), 110–121. https://doi.org/10.1111/1468-5973.12290

Curnin, S., & Owen, C. (2013). Obtaining information in emergency management: A case study from an Australian emergency operations centre. *International Journal of Human Factors and Ergonomics*, *2*(2–3), 131–158. https://doi.org/10.1504/IJHFE.2013.057614

Curnin, S., Owen, C., Paton, D., & Brooks, B. (2015). A theoretical framework for negotiating the path of emergency management multi-agency coordination. *Applied Ergonomics*, *47*, 300–307. https://doi.org/10.1016/j.apergo.2014.10.014

DeMarco, D. L. (2016). *A visual language for situational awareness*. Monterey, California: Naval Postgraduate School.

Deverell, E., Alvinius, A., & Hede, S. (2019). Horizontal collaboration in crisis management: an experimental study of the duty officer function in three public agencies. *Risk, Hazards & Crisis in Public Policy*, *10*(4), 484–508. https://doi.org/10.1002/rhc3.12179

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors*, *37*(1), 32–64. https://doi.org/10.1518/001872095779049543

FEMA (2014). *National Incident Management System (NIMS) Student Manual IS-700.A*. Communication and Information Management.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research notes on the Gioia methodology. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Groenendaal, J., & Helsloot, I. (2018). A closer examination of command and control practices by incident commanders during realistic operational exercises in the Netherlands. *International Journal of Emergency Management*, *14*(1), 51–71. https://doi.org/10.1504/IJEM.2018.089159

Hutchins, E. (1995). *Cognition in the Wild*. Cambridge, MA: MIT Press.

Kalkman, J. P., Kerstholt, J. H., & Roelofs, M. (2018). Crisis response team decision-making as a bureau-political process. *Journal of Contingencies and Crisis Management*, *26*(4), 480–490. https://doi.org/10.1111/1468-5973.12243

Klein, G. A. (1993). *A recognition-primed decision (RPD) model of rapid decision making*. Ablex Publishing Corporation New York.

Klein, G. A., Calderwood, R., & Clinton-Cirocco, A. (1986). Rapid Decision Making on the Fire Ground. *Proceedings of the Human Factors Society Annual Meeting*, *30*(6), 576–580. https://doi.org/10.1177/154193128603000616

Klein, G. A., Wiggins, S., & Dominguez, C. O. (2010). Team sensemaking. *Theoretical Issues in Ergonomics Science*, *11*(4), 304–320. https://doi.org/10.1080/14639221003729177

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management Review*, *24*(4), 691–710. https://doi.org/10.5465/amr.1999.2553248

Leedom, D. K. (2003). Functional analysis of the next generation common operating picture. *Analysis*, *69*(2), 149–163.

Looney, C. G. (2001). Exploring fusion architecture for a common operational picture. *Information Fusion*, *2*(4), 251–260. https://doi.org/10.1016/S1566-2535(01)00043-4

Luokkala, P., Nikander, J., Korpi, J., Virrantaus, K., & Torkki, P. (2017). Developing a concept of a context-aware common operational picture. *Safety Science*, *93*, 277–295. https://doi.org/10.1016/j.ssci.2016.11.005

McConnell, A. (2011). Success? Failure? Something in-between? A framework for evaluating crisis management. *Policy and Society*, *30*(2), 63–76. https://doi.org/10.1016/j.polsoc.2011.03.002

Merkus, S., Willems, T., Schipper, D., van Marrewijk, A., Koppenjan, J., Veenswijk, M., & Bakker, H. (2017). A storm is coming? Collective sensemaking and ambiguity in an inter-organizational team managing railway system disruptions. *Journal of Change Management*, *17*(3), 228–248. https://doi.org/10.1080/14697017.2016.1219380

Meso, P., Troutt, M. D., & Rudnicka, J. (2002). A review of naturalistic decision making research with some implications for knowledge management. *Journal of Knowledge Management*, *6*(1), 63–73. https://doi.org/10.1108/13673270210417709

Njå, O., & Rake, E. L. (2008). An essay on research methodology: An alternative approach to incident command research through participatory action research. *Journal of Contingencies and Crisis Management*, *16*(2), 91–100. https://doi.org/10.1111/j.1468-5973.2008.00537.x

Nja, O., & Rake, E. L. (2009). A discussion of decision making applied in incident command. *International Journal of Emergency Management*, *6*(1), 55. https://doi.org/10.1504/IJEM.2009.025173

O'Brien, A., Read, G. J. M., & Salmon, P. M. (2020). Situation Awareness in multi-agency emergency response: Models, methods and

applications. *International Journal of Disaster Risk Reduction*, *48*, 101634. https://doi.org/10.1016/j.ijdrr.2020.101634

Owen, C., Brooks, B., Bearman, C., & Curnin, S. (2016). Values and complexities in assessing strategic-level emergency management effectiveness. *Journal of Contingencies and Crisis Management*, *24*(3), 181–190. https://doi.org/10.1111/1468-5973.12115

Pfaff, M. S., Klein, G. L., Drury, J. L., Moon, S. P., Liu, Y., & Entezari, S. O. (2013). Supporting complex decision making through option awareness. *Journal of Cognitive Engineering and Decision Making*, *7*(2), 155–178. https://doi.org/10.1177/1555343412455799

Rimstad, R., & Sollid, S. J. M. (2015). A retrospective observational study of medical incident command and decision-making in the 2011 Oslo bombing. *International Journal of Emergency Medicine*, *8*(1), 4. https://doi.org/10.1186/s12245-015-0052-9

Salmon, P. M., Stanton, N. A., Walker, G. H., Baber, C., Jenkins, D. P., McMaster, R., & Young, M. S. (2008). What really is going on? Review of situation awareness models for individuals and teams. *Theoretical Issues in Ergonomics Science*, *9*(4), 297–323. https://doi.org/10.1080/14639220701561775

Sarter, N. B., & Woods, D. D. (1991). Situation awareness: A critical but ill-defined phenomenon. *The International Journal of Aviation Psychology*, *1*(1), 45–57. https://doi.org/10.1207/s15327108ijap0101_4

Schakel, J. K., & Wolbers, J. J. (2019). To the edge and beyond: How fast-response organizations adapt in rapidly changing crisis situations. *Human Relations*. https://doi.org/10.1177/0018726719893450

Scholtens, A. (2008). Controlled Collaboration in Disaster and Crisis Management in the Netherlands, History and Practice of an Overestimated and Understimated Concept. *Journal of Contingencies and Crisis Management*, *16*(4), 195–207.

Schwartz-Shea, P., & Yanow, D. (2009). *Reading and writing as method: In search of trustworthy texts*. Organizational ethnography: Studying the complexities of everyday life, 56-82.

Smith, K., & Hancock, P. A. (1995). Situation awareness is adaptive, externally directed consciousness. *Human Factors*, *37*(1), 137–148. https://doi.org/10.1518/001872095779049444

Tatham, P., Spens, K., & Kovacs, G. (2017). The humanitarian common logistic operating picture: A solution to the inter-agency coordination challenge. *Disasters*, *41*(1), 77–100. https://doi.org/10.1111/disa.12193

Taylor, R. M., & Selcon, S. J. (1990). Cognitive quality and situational awareness with advanced aircraft attitude displays. *Proceedings of the Human Factors Society Annual Meeting*, *34*(1), 26–30. https://doi.org/10.1177/154193129003400107

Treurniet, W., van Buul-Besseling, K., & Wolbers, J. J. (2012). *Collaboration awareness - a necessity in crisis response coordination*. Paper presented at the 9th International ISCRAM Conference, Vancouver, Canada.

Turner, B. A. (1976). The organizational and interorganizational development of disasters. *Administrative Science Quarterly*, *21*(3), 378–397. https://doi.org/10.2307/2391850

Uhr, C. (2009). *Multi-organizational emergency response management: A framework for further development*. Lund, Sweden: Lund University.

Van de Ven, J. G. M., Van Rijk, R., Essens, P. J. M. D., & Frinking, E. (2008). *Network Centric Operations in Crisis Management*. Paper presented at the 5th International ISCRAM Conference, Washington, DC, USA.

Van de Walle, B., Brugghemans, B., & Comes, T. (2016). Improving situation awareness in crisis response teams: An experimental analysis of enriched information and centralized coordination. *International Journal of Human-Computer Studies*, *95*, 66–79. https://doi.org/10.1016/j.ijhcs.2016.05.001

Vlaar, P. W. L., Fenema, P. C. V., & Tiwari, V. (2008). Cocreating understanding and value in distributed work: How members of onsite and offshore vendor teams give, make, demand, and break sense. *MIS Quarterly*, *32*(2), 227–255. https://doi.org/10.2307/25148839

Walker, W. E., Lempert, R. J., & Kwakkel, J. H. (2013). Deep uncertainty. In S. I. Gass & M. C. Fu (Eds.), *Encyclopedia of operations research and management science*. (pp. 395–402). New York: Springer.

Wimelius, M. E., & Engberg, J. (2015). Crisis Management through Network Coordination: Experiences of Swedish Civil Defence Directors. *Journal of Contingencies and Crisis Management*, *23*(3), 129–137. https://doi.org/10.1111/1468-5973.12048

Wolbers, J. J., & Boersma, F. K. (2013). The Common Operational Picture as Collective Sensemaking. *Journal of Contingencies and Crisis Management*, 186–199. https://doi.org/10.1111/1468-5973.12027

Wolbers, J. J., & Boersma, F. K. (2019). Key challenges in crisis management. In *The Routledge Companion to Risk, Crisis and Emergency Management* (pp. 17–34). New York, NY: Taylor and Francis.

Wolbers, J. J., Boersma, F. K., & Groenewegen, P. (2018). Introducing a fragmentation perspective on coordination in crisis management. *Organization Studies*, *39*(11), 1521–1546. https://doi.org/10.1177/0170840617717095

You, M., & Ju, Y. (2019). Salience of public leaders' "meaning making" in news coverage of a health crisis. *Journal of Contingencies and Crisis Management*, *27*(4), 400–405. https://doi.org/10.1111/1468-5973.12259

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APPENDIX
CODING STRUCTURES

Table A1 provides the code structure for the gas explosion case. The GMS registration consisted of 205 entries. For technical reasons, in this particular case there were no LCMS data available for analysis, but the LCMS did not play a very significant role in the Hollands-Midden safety region by that time, either. The on-scene command team did not even have access to the system. The decision-making process was based mainly on spoken accounts from team members and was captured in periodic meeting reports, and decision lists were a more important source of information. A seven-page decision list was available to complement the emergency centre registration. This decision list summarized the decisions taken by the team in charge of the tactical coordination.

TABLE A1 Coding structure for the gas explosion case

Key decision-making topics	Codes
Access restriction	Crime scene; CS; access control; raising of the barrier
Asbestos	Asbestos
Emergency accommodation	De Bron; Troubadourweg; Limeshal; Kees Musterstraat (details of accommodation)
Activation of municipal crisis organization	Municipality
Return of residents	House; release of building; apartment; utilities (energy, gas, electricity)
Victim list	1,000 (code for deceased person); victim; deceased; wounded
Stability of the apartment building	Stability; construction of building; structural condition; danger of collapse

Table A2 provides the coding structure for the mall shooting case. The GMS registration consisted of 39 pages, and the registration exported from LCMS consisted of 506 pages. The registrations contained 865 and 468 entries, respectively.

TABLE A2 Coding structure for the mall shooting case

Key decision-making topics	Codes
Public sentiments	Horror; bad news coverage; outrage; empathy; hearsay; rumours; sick minds; dismay; disrespect; understanding; speechless; compliment; amazement; disbelief; homage; criticism
Victim list	Number of casualties; victim overview; registration of casualties; triage category; identification/identity of casualties; information about hospitalized victims
Target groups	Victims; relatives; shopkeepers; neighbourhood residents; schools; general public
Harmonization of crisis communication	Information number; calling
Emergency accommodation	Emergency accommodation; emergency care; De Bron; Limeshal; police station; 30 (code for police station)
Multidisciplinary organization	Unit status; substitution; logistics; allocation of tasks and responsibilities; lines of command
Foreign affairs	Foreign countries; international; Syrian (the ethnic background of one of the victims)
Safety and security	Crime scene; safety and security of emergency workers; safety and security of bystanders and general public; precautionary measures
Transition to normalized situation	Prognosis; handover to project organization; aftercare
Psychosocial support	Psychosocial support to emergency workers; psychosocial support to others involved; fire service mental support team
Disaster tourism	Disaster tourism
Looking after properties	Real estate; goods left behind in the rush to leave

Table A3 provides the coding structure for the collapsed cranes case. The GMS registration consisted of 24 pages, and the registration exported from LCMS consisted of 1,240 pages. The registrations contained 540 and 510 entries, respectively.

TABLE A3 Coding structure for the collapsed cranes case

Key decision-making topics	Codes
Status of the various addresses	Street names; address; house; shop; building; utilities (gas, electricity)
Movement of pontoons	Stable; stability; movement; buckling of the quay
Victim list	Victims; wounded; persons; victim information system
Emergency accommodation	Emergency accommodation; location indicators (Chinese restaurant; restaurant "De Meiden"; Tulip Inn; Avifauna; Goede Herderkerk [Good Shepherd Church]; Schiphol); persons
Communication	Communication; message; informing; meeting; press; media
Access restriction	Crime scene; emergency regulation; investigation; investigation agencies; access control; blocked
Transition to normalized situation	Aftercare; follow-up phase; project; scaling down