THE ROLE OF ATMOSPHERIC DISPERSION MODELLING SYSTEMS AND EXPERTISE IN CRISIS SITUATIONS A METHODOLOGY TO ASSESS THEIR SUPPORT TO CRISIS COMMAND CENTER

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Abstract: This paper focuses on the support of Atmospheric Dispersion and Impact Assessment Modelling (ADIAM) in radiological or chemical emergency situations. After introducing the question of ADIAM results and expertise use during crisis situations, the paper presents a methodology developed to characterize their support to stakeholders in charge of population protection. Data are collected through the observation of radiological and chemical crisis exercises at a command centre level and coded through four main categories: information percolation, use of tools, communication style and communication content. We highlight how this methodology allows analysing coordination patterns between ADIAM advisors and stakeholders in a crisis command centre and the contribution of ADIAM to situation assessment and management.

Key words: *emergency management, dispersion and impact assessment modelling, decision support system, scientific expertise, civilian protection.*

INTRODUCTION

The Atmospheric Dispersion and Impact Assessment Modelling (ADIAM) has become an essential tool in the study of potential hazardous atmospheric releases. If they are mainly operated in pre-crisis contexts (R&D, risk management and training), the Fukushima nuclear accident demonstrated the ability of several organizations across the world to use them operationally in real-time in order to diagnose or forecast the radiological situation in addition to measurements. Providing estimations of impacted areas and health impacts, their results are useful as an additional support regarding civilian protection decision making. Consequently, ADIAM systems are more and more developed as decision support tools for emergency situations (see for e.g. Bradley, 2007; SØrensen et al., 2007).

THE QUESTION OF ADIAM RESULTS AND EXPERTISE IN EMERGENCY SITUATIONS

If the statement expressed in the introductory paragraph can be formulated quite easily, its operational application still raises many issues as illustrated during the Fukushima nuclear accident regarding the constraints associated to crisis management such as uncertain conditions, time-pressure and high stakes. This highlights the need of clarification of the kind of support ADIAM tools and expertise can provide during emergency situations (Benamrane et al., 2013).

Analyzing ADIAM input and output data as a function of importance, availability and reliability criteria in nuclear emergency phases (Zähringer & Wirth, 2007) can provide a first answer. However, this approach is limited in grasping the complexity of the decision context characterized by the structure level of the decision problem, management activities (operational, tactic and strategic) and the situation's level of uncertainty (Gory & Scott Morton, 1971). ADIAM use is also mainly grounded in a social context at the boundary between scientific organizations which develop and operate them and emergency decision makers in charge of population protection countermeasures. The issue of sharing knowledge between both organizations is known as a main contributor of the difficulties linked to ADIAM use in addition to their results accuracy in uncertain conditions (French *et al*., 2007). If the distance between ADIAM development and the emergency management process is well identified, nuclear emergency handling is increasingly based on a close cooperation between both organizations in order to bring back the technical situation in a stable state while taking adequate population protection countermeasures.

In order to analyze coordination practices during emergency and crisis situations, we designed an observation protocol for crisis exercises. We argue that *in-situ* observations that grasp the dynamics of facts in their context and their associated constraints can contribute to better assess to what extent ADIAM results and expertise can be of help to emergency decision makers. It allows to go further than classical approaches focusing on the strict application of rules, plans and procedures and to identify how individuals and teams use coordination mechanisms, situation opportunities and objects, such as plans or softwares, to coordinate actions more efficiently (Suchman, 1985, Wybo & Latiers, 2006).

DATA COLLECTION AND CODING METHODOLOGY

Data collection

The collection of empirical data is performed through the observation of radiological and chemical crisis exercises performed in crisis command centres at the departmental level (called COD thereafter). In the French crisis organization, the COD is activated when an emergency occurs that impact several municipalities of a department or overflow the municipality's capacity to respond to the event. In such a case, the Decision Maker (DM) is the Department Prefect who endorses the responsibility of the response operations. The COD gathers stakeholders of different skills from several organizations of the civilian protection and security (police forces, health services, fire brigades, etc.) which need to coordinate rapidly.

Data are collected by one "*in-situ*" but non-participative observer. The aim is to assess coordination and communication processes between COD actors and scientific advisers. Before scientific advisers' arrival, observation focuses on explicit oral communication between COD teams. When scientific advisers arrive in the COD, the observation mainly focuses on their activities and interactions with COD participants. Data are collected through audio recording and handwriting notes. The verbatim of each exercise is transcribed in order to be analysed qualitatively and quantitatively.

Data coding

A large part of this research aims to elaborate coding categories in order to analyse data collected during observations. Data are analysed through four main categories: information percolation, use of tools, communication styles and communication contents.

Information percolation is based on the study of information communication between COD teams. Indeed, the construction of a situation operating picture can be distributed between actors at the beginning of the emergency management. Thus, achieving a certain level of collective situation awareness needs to take in consideration how this representation is propagated through the system in temporal coherence with the situation's dynamics and information lifetime (Artman & Garbis, 1998; Wybo, 2012). Three communication patterns have been identified. Broadcasting allows one team (police for instance) to transmit information simultaneously to all COD stakeholders. It is the main communication mode during briefings and when a team receives information that they perceive as crucial for all COD participants. Talking in limited groups seems to be mainly used in management phases where a mission doesn't require all the COD teams to be mobilized on a subject. Individual communication (one team to another) has been observed under two main forms: a proximity communication and a communication at distance allowing "floating ears" mechanism.

The observation and report from observer's handwriting notes allows analysing the use of artifacts in the exchange of information between COD teams as a support to the construction of a common operating picture of the situation (white boards, maps and ADIAM cartographic results).

Communication styles allow characterizing more precisely verbal exchanges between teams. An analytical taxonomy, presented in Table 1, has been developed based on group coordination literature (Boos et al. 2011) and observation data.

Finally, communication contents allow studying the different matters addressed by the crisis centre. Height main stakes have been identified from collected data: "General situation assessment", 'CBRN-E situation assessment", "Emergency plans", "Traffic regulation", "Civilian security organization and means", "Internal coordination management", "Public and media information", "Population protection countermeasures".

Table 1. Analytical taxonomy of communication types in the crisis command centre.

Questions	**"Requesting information", "Requesting opinion", "Requesting decision", "Requesting solution", "Questioning information", "Requesting agreement", "Requesting about needs", "Requesting attention", "Requesting team role", "Requesting acknowledgement", "Requesting procedure"**
Content related statement	**"Indicating procedure", "Deciding", "Giving the floor to somebody", "Summarizing", "Goal setting", "Prioritization", "Solution analysis", "Assigning task or responsibilities", "Problem definition and elaboration", "Suggesting task", "Taking responsibility of a task or a request", "Providing information", "Indicating a need", "Providing opinion", "Declaring", "Appreciation", "Providing clarification"; "Agreeing", "Disagreeing", "Acknowledgment", "Verbalizing interpretation of a situation", "Verbalizing own behaviour", "Situation evolution anticipation"**

RESULTS

This paper presents the first results regarding how the developed methodology allows analyzing coordination patterns between ADIAM advisors and COD stakeholders and their contribution to situation assessment and management. For this purpose, it was applied to two radiological training exercises observed in October 2013 and February 2014.

Exercises presentation

Both exercises were designed and hosted by the French National Institute for Advanced Studies in Security and Justice (INHESJ) which is a national public administration under the supervision of the French Prime Minister. The exercises consisted in tabletop exercises that reproduce a COD.

Both exercises were performed on the same scenario: a terrorist attack in a metropolitan train station implying the release of radiological material. The exercises are conducted during three hours, simulating the first hours of the event, when the uncertainty regarding the situation in the field is maximum. They involve the construction of a common operating picture of what happens in the field via the emergency services' reports to take adequate countermeasures requested by the events. These reports are delivered (by mails and phone calls) by the INHESJ animation team that plays the upper and lower levels of the French crisis organization surrounding the COD level, as well as the media pressure.

The French public health legislation (Art R 1333-81) states that the Department Prefect can require the relevant expertise that allows assessing the situation and its potential evolutions in order to take adequate countermeasures. Thus, an ADIAM scientific advisor takes part in both exercises by providing its expertise to the COD.

Actors' interactions study

The analysis of scientific advisor interactions with the COD cells for both exercises is presented in Figure 1. Each colour area gathers specialized teams: police forces in light blue, Defence forces in dark blue, health cells in red, external advisors in grey, communication cells in green, decision cells in yellow and transport cells in purple. The radial scale represents the exchange frequency of the scientific advisor with the different teams *i.e.* the greater the exchanges with the scientific advisor, the nearer to the centre of the figure.

In both exercises, similar patterns can be underlined regarding the interaction of the scientific advisor with the COD: the advisor collaborates mainly with health and decision teams. Interactions with firefighters can be explained by the fact that they are the first source of information regarding radiological measurements in the field at the beginning of the emergency management. Strong interactions also take place with the decision team and more precisely with the decision maker (the Prefect in the first exercise and his deputy, DIRCAB, in the second one). To better apprehend what these interactions represent in regard to decision makers interactions with the COD, Figure 2 shows the same analysis focusing on decision maker's interactions. In both exercises, it illustrates that decision maker's interactions with the scientific advisor are quite similar to those with firefighters with whom Decision Makers are more to collaborate. The COD's radiological situation assessment mainly emerges from interactions between scientific advisors, firefighters and decision makers.

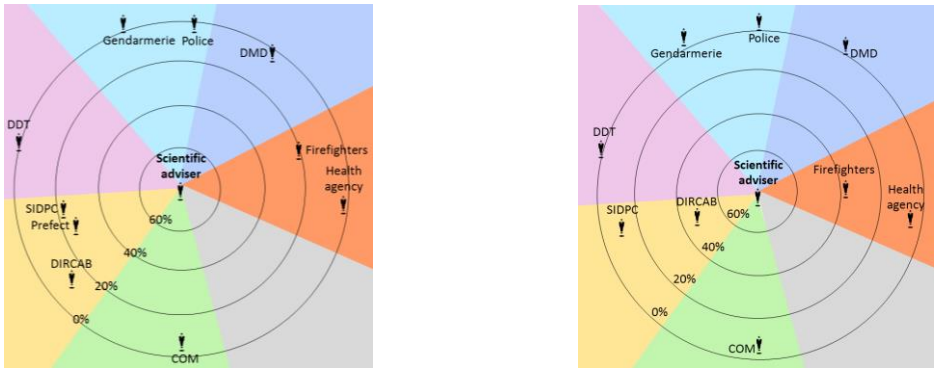

Figure 1. Comparison of interactions between the scientific adviser and COD teams.
Left: October 2013 exercise; right: February 2014 exercise. Radial scale: exchanges frequency.

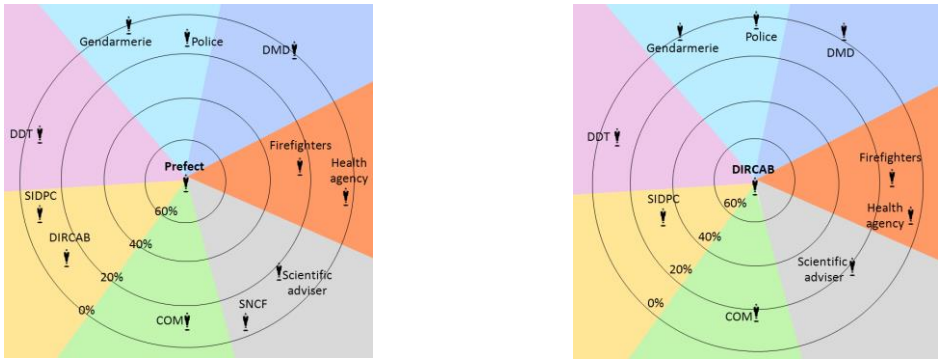

Figure 2. Comparison of interactions between the decision maker and COD teams.
Left: October 2013 exercise; right: February 2014 exercise. Radial scale: exchanges frequency.

Communication distribution between situation assessment and management

Codification sub-categories regarding communication styles allow to assess the contribution of exchanges relating to situation assessment and management. Figure 3 shows the distribution of communications between ADIAM advisor and the COD for both exercises. Although main interactions with ADIAM advisor deal with situation assessment, he also provides opinion about situation management and actions especially regarding the evolutions of population protection perimeters.

These results allow better assessing the crossing of role specification between scientific advisors and decision makers, described in the crisis management literature: depending on the crises context, experts may move into decision making roles and / or decision makers may give too much leeway to scientific advisors (Rosenthal and ‘t Hart, 1991).

Distribution differences between both exercises can be explained by the fact that during the October 2013 exercise, the Prefect and his Deputy were playing their own roles. It was not the case during the February 2014 exercise in which the role of the Prefect’s Deputy was played by a Police Commissioner who was not used to endorse such responsibilities and was more in demand of ADIAM advisor’s opinions.

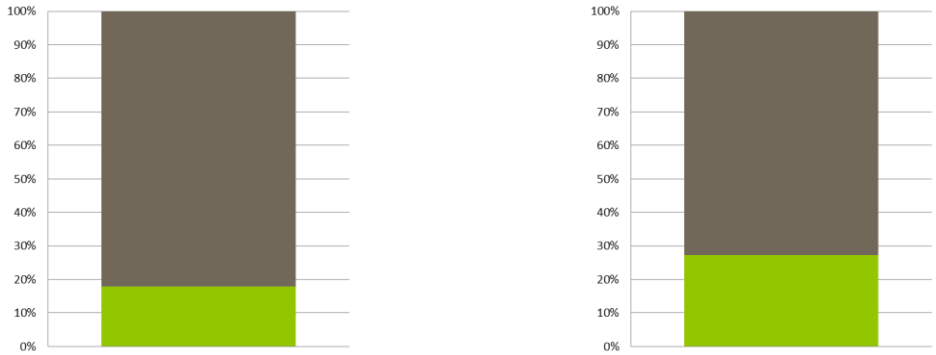

Figure 3. Quantitative distribution of interactions regarding situation assessment (grey) and situation management (green) between COD cells and the ADIAM advisor during the October 2013 exercise (left) and the February 2014 exercise (right).

CONCLUSION

This paper presented the development of a methodology to assess the support of ADIAM expertise and results to crisis command centre stakeholders. Data are collected through the observation of crisis exercises at command centres allowing assessing coordination patterns between ADIAM advisors and crisis command centre stakeholders and his or her contribution in situation assessment and management.

On-going and future work will more specifically analyse the use of ADIAM cartographic results as a support to build common situation awareness and a better collaboration between crisis teams. The research needs also to integrate data from different experimental fields. INHESJ crisis training events have three main biases regarding national crisis exercises: (i) participants don't know each other before the exercise; (ii) they don't know necessarily the area in which the scenario takes place; (iii) they are not familiar with the tools used during the exercises. In order to address these biases, this methodology will be applied on two national-level exercises simulating a chemical terrorist attack exercise and an accident affecting a nuclear power plant.

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