Dewald Van Niekerk, Christo Coetzee*, Doret Botha, Michael John Murphree, Kristel Fourie, Tanya Le Roux, Gideon Wentink, Leandri Kruger, Lesego Shoroma, Kylah Genade, Suna Meyer and E. Annandale

Planning and Executing Scenario Based Simulation Exercises: Methodological Lessons

Abstract: The South African disaster management legislation advocates the importance of implementing pro-active disaster risk reduction strategies that will ensure a safe and sustainable society. One key strategic activity identified is the use of simulation exercises to improve overall societal readiness and inter-agency coordination in case of major incidents or disasters. However, very little is currently understood or planned especially at South African local government level, on what simulation exercises entail and the methodology behind their implementation. This paper aims at conveying some crucial methodological inputs that disaster risk managers or emergency response agencies should consider when planning, designing and implementing simulation exercises by analysing a hazardous chemical spillage simulation in the Tlokwe Local Municipality, North-West Province, South Africa. The research found that in the South African context attention needs to be paid to methodological issues such as scenario development, role-player selection, fidelity during simulation delivery, data collection and participant (de)briefing.

Keywords: contingency planning; emergency response; simulation; methodology; risk reduction.

DOI 10.1515/jhsem-2013-0077

***Corresponding author: Christo Coetzee,** African Centre for Disaster Studies, North West University Potchefstroom Campus, 11 Hoffman Street Potchefstroom, Potchefstroom, North West Province 2520, South Africa, e-mail: christo.coetzee@nwu.ac.za
Dewald Van Niekerk , Doret Botha, Michael John Murphree, Kristel Fourie, Tanya Le Roux, Gideon Wentink, Leandri Kruger, Lesego Shoroma, Kylah Genade, Suna Meyer and E. Annandale: African Centre for Disaster Studies, North West University Potchefstroom Campus, Potchefstroom, North West Province, South Africa

1 Introduction

Since the onset of democracy in South Africa in 1994, the country has undergone a variety of dramatic changes in all aspects of society. One such change occurred in the field of disaster risk management, whereby the new disaster management legislation, the Disaster Management Act 57 of 2002, places a legal obligation on all levels of government to move away from purely reactive disaster response mechanism, towards more pro-active disaster prevention and mitigation in both planning and implementation (Pelling and Holloway 2006; Van Niekerk 2014a). Included in this imperative, is the need for the different levels of government, emergency response agencies, private sector institutions and community representatives, to cooperate in conducting simulation exercises to ensure improved disaster response. However, although legislation identifies simulation exercises as a fundamental component in the move towards a more pro-active approach to disaster risk management, very little is understood especially at local government level in South Africa, on what simulation exercises entail, as well as the methodology behind its implementation. This paper aims to convey some methodological and practical lessons which disaster risk mangers and emergency response agencies should consider when planning, designing and implementing simulation exercises by investigating a hazardous chemical spillage simulation (as a case study) undertaken in the Tlokwe Local Municipality, North-West Province, South Africa.

2 Literature Study

To gain a holistic picture of the methodological aspects to consider when planning, designing and conducting simulation exercises an exploration on existing simulation literature was undertaken. Specific attention was given to gathering information on the nature and types of simulation exercises and the methodological lessons that could be learned from past simulation exercises. A wide array of literary resources were used. The findings from this literature review relating to the types of simulation exercises, the lessons learned, and potential variables that may influence simulations, will be discussed to give greater clarity.

2.1 Types of Simulation Exercises

Various scholars agree that the changing nature of disasters and mass casualty emergency necessitate a greater degree of preparedness and pre-planning in

order to be effective (Paton and Flin 1999: p. 263; Paton and Jackson 2002: p. 115; Green et al. 2003: p. 689; Moats et al. 2008: p. 397–398). In this context, various simulation methodologies have been developed by academics and practitioners to assist emergency personnel working in mass casualty events to improve their planning in terms of reaction times, decision-making, cooperation and communications (Alexander 2000: p. 89; Paton and Jackson 2002: p. 115; Green et al. 2003: p. 690; Bruinsma and de Hoog 2006: p. 54). From emergency management literature four broad groups of simulation exercise emerge: desktop or discussion based exercise, computer based exercises, command post exercises, and live reconstructions (Smith et al. 1999: p. 122; Green et al. 2003: p. 690; Hammond 2005: p. 269; Heumüller et al. 2012).

2.1.1 Desktop or Discussion-Based Exercises

According to Smith et al. (1999: p. 119), desktop exercises are often employed by emergency management trainers to facilitate integrated emergency management simulation exercises where various role-players, who would traditionally be involved in mass emergency or disaster events, are brought together. The defining characteristic of such simulations is that they are presented as textual narratives on paper and are not actualized as full-scale real life simulations (Payne 1999: p. 115; Smith et al. 1999: p. 119). Due to technological advancements, these simulations are supplemented with video-streaming, GIS-maps and computer-based models (Payne 1999: p. 115; Smith et al. 1999: p. 119). The overall goal of desktop exercises are to provide an analogy of a real life disaster or mass casualty event (Chi et al. 2001), where the coordination and response of multiple role-players can be tested, without any of the dangers and cost associated to real life simulations (Smith et al. 1999: p. 122). Two types of desktop simulation emerge from literature, namely scenario planning and scenario-based training.

2.1.1.1 Scenario Planning

According to Moats et al. (2008: p. 401) and Zegras and Rayle (2012: p. 303) the inherent strength of scenario planning as a planning or simulation method, lies in the fact that it provides decision makers with a tool that considers multiple possible outcomes to any future event being simulated. This is echoed in the work of Pierre Wack (1985), who is arguably the father of scenario planning. As such it adds value and challenges preconceived ideas that emergency responders might have of actions to address the emergency situation (Payne 1999: p. 115; Alexander 2000: p. 93; Moats et al. 2008: p. 401). According to Moats et al. (2008: p. 402) the

scenario planning process is generally made up of four broad phases, namely, (1) defining the scope of the scenario project, (2) formulating a holistic picture of a situation by taking into account both the internal and external environment, (3) creating an actual scenario out of the previous phases, and (4) applying scenario to test strategies and decision making. Schoemaker (1993: p. 197) lists 10 steps in scenario construction, which are aligned with those of Moats et al. Throughout all these steps, the method aims at broadening emergency responders' thinking on possible emergency events and various responses that can be initiated to deal with variations happening in such events (Alexander 2000: p. 93; Moats et al. 2008: p. 402). For the most part, scenario planning exercises are paper based, which makes it ideal in settings where budgets might not be available to implement live simulation exercises. Additionally the paper based nature of scenario planning also helps to keep track of people's perception and changes, by giving pictures and analysis on paper (permanent) instead of relying solely on the training officer and his/her understanding/perception.

2.1.1.2 Scenario-Based Training

In contrast with scenario planning, which explores various theoretical possibilities that might occur within any emergency situation, scenario-based training (SBT), places participants into a specific situation that resembles a real life emergency and generates the scenario according to the decisions taken by participants (Smith et al. 1999: p. 119; Alexander 2000: p. 90; Moats et al. 2008: p. 401). Scenario-based training comprises of three distinct phases, namely scenario development, delivery, and debriefing. To contribute to the learning process envisaged by this method, simulation controllers usually introduce "decision points" throughout the course of the exercise (Payne 1999: p. 115; Alexander 2000: p. 93). Decision points are specific "sub-plots" within the scenario purposely designed to test specific aspects of the emergency response, such as decision making, communication, control, and coordination (Payne 1999: p. 115; Alexander 2000: p. 93; Moats et al. 2008: p. 402). The testing of specific aspects or dimensions of an emergency provides emergency personal with the opportunity to improve their command and decision making skills (Payne 1999: p. 115; Alexander 2000: p. 90; Moats et al. 2008: p. 402).

2.1.2 Computer-Based Exercises

Computer-based simulation exercises help to eliminate many of the cost and dangers associated with traditional simulation exercises by imitating the dynamic

of a disaster domain through the application of computer based channels such as video, audio and computer graphics (Kincaid et al. 2003: p. 239; Bruinsma and de Hoog 2006: p. 54; Wilkerson et al. 2008: p. 1153). Prominent examples of computer-based systems include the *Plowshares, CAVE* (Cave Automatic Virtual Environment) and *HPS* (Human Patient Simulator) systems in the USA; the *Minerva* and *Vector* systems in the UK and the BRAHMS multi-agent modeling and simulation language in the Netherlands. Some innovative and new models is also seeing the light, such as the agent-based simulation system developed by Wagner and Agrawal (2014). These computerized systems are used to test an array of disaster response activities such as incident command, coordination between response agencies, agent behavior, and incident communication (Smith et al. 1999: p. 122–123; Kincaid et al. 2003: p. 240; Bruinsma and de Hoog 2006: p. 54; Wilkerson et al. 2008: p. 1153). The research of Olson et al. (2012) show the effectiveness of computer-based exercises for learning and adaptation. Renda-Tanali and Abdul-Hamid (2011) argue that computer-based (online) simulations adds immense value to the overall learning experience and knowledge retention of students.

In a developing world context, accessibility of computer-based simulation software and hardware should also be enhanced if this type of exercise is to be generally accepted at a national scale, because it is currently only a viable training tool in developed countries that can afford the hardware and software (Smith et al. 1999: p. 122–123).

2.1.3 Command Post Exercises

Command post exercises has its origin within the military aimed at "battle application" (Keene et al. 1990). Also referred to as CPX, command post exercises involve the simulation of an army commander, staff and communication within and between headquarters. This type of exercise is typically aimed at tactical and strategic activities and relies heavily on the abilities of the controllers to generate realistic tactical information streams. Heumüller et al. (2012) believe that command post exercises are difficult to plan and evaluate because staff processes are less tangible and unstructured, compared to traditional exercises at operational level.

2.1.4 Live Reconstructions

According to Smith et al. (1999: p. 122), live reconstruction exercises have their roots in traditional military exercises, where full-scale recreations of actual

events, complete with victims and active hazards, are simulated in order to replicate the chaotic nature of actual disasters or mass casualty events. The overall purpose of this type of simulation is to expose emergency personnel to the pressure of a real life event, and to test their decision making, coordination and communication abilities in an environment under real pressure (Paton and Flin 1999: p. 263; Payne 1999: p. 115; Smith et al. 1999: p. 122). Although live reconstruction exercises provide the closest setting to a real life event, they are often costly conducted, lacks immediate spontaneity, and may put the lives of participants at risk (Payne 1999: p. 115–116; Kincaid et al. 2003: p. 239; Bruinsma and de Hoog 2006: p. 54). These dual drawbacks associated with live reconstructions have lead to the emergence of computer based exercises as a method of testing emergency and disaster response capabilities of response agencies (Smith et al. 1999: p. 122).

2.2 Lessons Learned and Variables Observed in Conducting Simulation Exercises

One aspect that emerges from past simulation exercises is the need to continually adapt the dynamics of simulations to real world factors, such as changes in disaster response legislation, operational and managerial practices of response agencies, the interaction between multiple response agencies and changes in theories about disaster and disaster response (Paton and Flin 1999: p. 263; Smith et al. 1999: p. 124; Kincaid et al. 2003: p. 246). If these dynamics are not taken into account, simulation exercises loose their effectiveness as a planning tool, because response efforts are not tested against factors that will directly affect the efficiency of real world response (Smith et al. 1999: p. 129; Green et al. 2003: p. 698).

Regarding the methodology to be used in assessing simulation exercises, Green et al. (2003: p. 697) state that it is crucial to decide on the role of observers and observation methods to be followed before a simulation exercise is initiated. Specifically it has been established that it is preferable for external observers to monitor an exercise and capture data on various aspects such as incident command, coordination and patient evacuation, rather then passing the monitoring duty to one of the direct participants. This is because most participants are usually working on an operational level during an exercise and would not have time to evaluate or reflect on their own performance (Green et al. 2003: p. 697–698).

It is also crucial that the methodology (i.e., how many researchers are needed, what they need to observe) be established before an actual exercise. This needs to be done as past simulations have shown that it is difficult for only a handful

of observers to monitor the interaction and movements of multiple role-players involved in a simulation exercise (Green et al. 2003: p. 697–698).

The literature review has helped in establishing that simulation exercises are useful tools for measuring the effectiveness and possible deficiencies that may exist in how emergency response agencies approach mass causality or disaster events. The training provided by either computer based, live reconstruction and desktop simulations provides a mechanism through which the skills and competency of emergency responders can be drastically improved (Chi et al. 2001). It is crucial that when simulation exercise are being planned, cognisance should be taken of the lessons learned and variables observed during previous simulation exercises, to ensure that the right variables that would contribute to the improvement of emergency response to be measured.

The sections to follow will discuss some methodological and practical aspects of desktop simulation exercises that was developed and implemented by the African Centre for Disaster Studies (ACDS) in the Dr. Kenneth Kaunda District Municipality (South Africa).

3 Methodology

It is often impossible to gain experience from a particular phenomenon except by simulating it (Kleiboer 1997). The success of evaluating simulations is directly related to the robustness of its assessment methodology (Olson et al. 2012). To determine how a simulation should be evaluated, three constructs of the simulation evaluation are important: fidelity (level of realism of the simulation); verifiability (is the exercise operating as it should?); and validity (does the simulation test what it intended (Feinstein and Cannon 2002). All three these constructs need to present and observable for a simulation exercise to be considered a successful scientific and practical endeavor. Their importance to the success of simulation exercises warrants more detailed description within the context of the case study.

3.1 Fidelity

Fidelity, according to Feinstein and Cannon (2002: p. 426) defines the similarity between training exercises and the operational situation. It relates to the similarity in the physical (e.g., visual, spatial) as well as the functional characteristics (e.g., flow of information, decision-making). However, Feinstein and Cannon (2002) argue that many studies show that a higher level of fidelity does not neces-

sarily translate into more effective training, due to the possibility of over stimulating participants. In contrast Issenberg et al. (2005) show through their research that high fidelity medical simulations facilitate learning under the correct conditions. The simulation exercise under investigation opted to use medium fidelity and focused on an actual hazard affecting the Tlokwe Local Municipality (falling within the geographical boundaries of the Dr. Kenneth Kaunda District Municipality), namely hazardous chemical spills. The Nuclear Fuels Corporation of South Africa (NUFCOR) transports low radiation (alpha and beta) nuclear materials on a weekly basis through the city center of the Tlokwe Local Municipality within the North-West Province of South Africa. In the event of an accident or spill a specialized multi-agency response would be required. Prior to the planned simulation exercise limited to no knowledge existed of this particular hazard with most of the traditional response agencies. Consequently to add to the fidelity of the simulation, prior briefings of all stakeholders was held. A decision was made to simulate this event through a desktop exercise. A number of variables to the simulation were identified and a brainstorming session was used to consider all possible actions emanating from the scenario. The chosen simulation was also aligned with the objectives of a number of response agencies such as: ensuring coordinated command and control; address escalating levels of responsibility and resources allocation; effective communication; and coordination.

3.2 Verifiability

The verifiability of the simulation was ensured through pre-determined rules. These rules set certain boundaries or parameters, which would be needed in a non-realtime desktop exercise. This included the physical layout of the desktop exercise, communication modes and channels, time intervals (such as one simulated minute relate to three real-time minutes), role and responsibilities of the various groups engaged in the simulation, and time outs. Four different groups were identified: players (main and secondary); controllers; evaluators; and observers. The ***players*** consisted of participants with a direct responsibility for actions/activities during an emergency or extraordinary event. Normally, the players would be in possession of some form of plan which aims at saving lives, protecting property and the environment, or at safeguarding public health and well-being (such as contingency plans). Players were required to make decisions based on the scenario and information supplied by the scenario controllers. Players were therefore involved in the decision-making process depending on the need for their direct involvement. The ***controllers***' role was to ensure that the exercise objectives were met sufficiently enough to permit evaluation, that

the level of activity kept players occupied and challenged, and that the pace of the exercise proceeded according to the agreed upon scenario and scenario rules. Controllers answered players' questions and resolved issues as they arose while monitoring the safety of the exercise. The ***evaluators*** were independent researchers assigned to "shadow" each major player. Their primary role was to observe actions taken by players and to record their observations. The evaluators' efforts provided the major portion of the documentation necessary to critique the exercise and produce an exercise report. The evaluators also assisted the controllers in keeping the exercise on track, but did not interfere with the players in the performance of their duties. Evaluators were assigned to the following three segments: incident command, communication, and decision-making. ***Observers*** were tasked to provide general observations (as opposed to the role-specific player observation provided by the evaluators) on the overall progress of the simulation. The observers captured data through a time-stamp method linked to various actions, communication and decisions taken by the players.

3.3 Validity

The validity of the simulation was enhanced through the pre-exercise briefing and joint planning by the various role-players. The evaluators and observers thus had insight into the aspects which the players wanted to have evaluated (e.g., How good is our communication? How well are we managing the scene? etc.). In addition to the pre-exercise briefing, the players were requested in advance to provide the controllers with their existing contingency plans and standard operating procedures, which were used as a benchmark for evaluation.

3.4 Data Capturing

Data capturing was a complex and calculated activity during the scenario implementation. The collection of information was carried out following two approaches, utilizing various methods. The first approach included the use of stationary video camera to document the movement of persons, the interactions of players, and the general verbal communications of the players. The second approach was based on the collection of written documentation provided directly from the players as the simulation unfolded. All players were required to document formal decisions on pre-designed decision-making forms, linked to time periods. Controllers and observers took notes during the exercise to document discussions, processes, inaction/action and non-verbal cues by the players.

Observers with time keeping assignments documented the timeframes of decisions and activities, and plotted them on a time sheet. Following the completion of the exercise a debriefing session was held where the participants voiced their own observations and comments on the simulation. These comments and observations were used as an additional data source.

3.5 Data Analysis

The analysis of the simulation data followed a traditional inductive approach. The methodology submits to a clear list of actions necessary to fulfill qualitative analysis. In the first instance the transcripts from players, observers and controllers were condensed into a summarized format. This enabled the analysis to more easily identify links between the research objectives and the data. Categories and subsequent broad themes were recognized and identified. A coding frame was developed based on the emergent themes. The transcripts were again reviewed with the coding structure as the guiding criteria. The final stage allowed for the evaluation of the findings to serve as the foundation of resulting recommendations and suggestions.

4 Discussion

The desktop simulation exercise discussed in this article can be classified as a Scenario Based Training since participants were given a specific scenario, which is based on an actual risk (Smith et al. 1999: p. 119; Alexander 2000: p. 90; Moats et al. 2008: p. 401). Moats et al. (2008: p. 404) propose three parts in executing Scenario Based Training: scenario development, delivery and after action. The section below is structured to discuss the activities surrounding the three different parts of the desktop simulation exercise held in the Tlokwe Local Municipal area, in order to extract lessons learned.

4.1 Pre-Planning of Simulation – Scenario Development

Scenario development, as the first part of executing a scenario-based training, begins with determining the scope and intent of the scenario, with the help of key role-players to be involved in the delivery of the simulation (Moats et al. 2008: p. 404). This step is crucial as it ensures that the scenario developed is contextu-

ally appropriate and aligned with the needs of all participants. The African Centre for Disaster Studies was approached by the South African Police Services (Visible Policing Cluster) in Potchefstroom, in conjunction with the Tlokwe Local Municipality Disaster Risk Management Centre (TLM DRMC), the Dr. Kenneth Kaunda District Municipality Disaster Risk Management Centre (KKDM DRMC) as well as the North-West Provincial Disaster Risk Management Centre (NWP DRMC), to assist in the testing of their response, decision-making, communication and planning capabilities. The above-mentioned role-players indicated that the risk of a hazardous material spill in the urban area of the Tlokwe Local Municipality is a valid concern and response capacities need to be tested through simulation.

Hence a meeting was held to involve and receive input from all relevant role-players. Various government departments, volunteer organizations and private sector entities were present at the initial planning meeting (see Table 1), although not all response agencies were represented. Involving most of the role-players made it possible to keep the scenario relevant. The research team could therefore include information from role-players and plan better for the simulation to ensure medium fidelity. Furthermore, it allowed the research team to evaluate decision-making and communication more effectively because they knew which information was relevant and necessary to the scenario. With the intent of the scenario

Table 1 Role-Players Involved in Simulation.

Government Department/ Entities	Private Sector Entities	Volunteer/Non-Profit Organizations
South African Police Service (Visible Policing)	Tlokwe Chambers of Commerce	Society for the Prevention of Cruelty to Animals (SPCA)
Potchefstroom Emergency Medical Rescue Services	Nuclear Fuels Corporation of South Africa (NUFCOR)	Tlokwe Local Municipality Fire Protection Association
City of Matlosana Disaster Risk Management Centre (neighboring municipality)	Agri North West	Community Policing Forum
South African Police Services Crime Intelligence	ALS Group (private construction and earth moving company)	Disaster Management Potchefstroom Volunteers
Tlokwe Local Municipality Disaster Risk Management Centre	ER24 Potchefstroom (private paramedic entity)	African Centre for Disaster Studies (North-West University)
Dr. Kenneth Kaunda District Municipality Disaster Risk Management Centre		
Department of Agriculture, Forestry and Fisheries		

already established, the initial meeting with relevant role-players greatly contributed to determining the scope of the scenario to be developed.

After the initial meeting of all the role-players, the steps for the preparation of the simulation process was agreed to be the following:

- Preplanning phase;
- Research case studies on response situations;
- Capacity assessment by all role-players involved; and
- Desktop research and debrief.

Following the initial engagement of role-players to determine the scope of the simulation, the next step in the process was the designing of the simulation.

4.1.1 Designing of Simulation

According to Moats et al. (2008: p. 404), once the intent and the scope of the planned scenario have been established a point is reached to develop the scenario further by compiling a detailed storyline and including planned decision points. The initial meeting with all role-players provided the opportunity to establish the main elements that would be included in the scenario. These elements were: (1) Hazardous material transport collision with another vehicle; (2) wildfire caused by the accident; (3) multi-car pile-up; and (4) radioactive material in the town's water supply. As the "storyline" developed, some of the elements contexts changed to accommodate the learning objectives and to include the necessary decision-making points. The final scenario therefore presented to the participants as part of a briefing session on the simulation day was:

> *"During the winter season, at approximately 17:00, a NUFCOR vehicle carrying Ammonium Diuranate (ADU) is hijacked just outside of Potchefstroom. The accompanying safety vehicle has been neutralized. The vehicle is spotted by the SAPS Air wing, while driving through Potchefstroom. A chase ensues which culminates in the hijacked vehicle colliding with stationary vehicles next to the Mooi River Mall. The tanker overturns, it is partially damaged and find itself in close proximity of the Mooi River. At least seven cars are involved in the accident. Some wildfires are already raging in other parts of the municipality due to the normal wildfire season."*

The scenario brief also included the aims and objectives of the exercise, purpose of the desktop exercise and the explanation of the groups involved. The above information was given to participants two weeks prior to the simulation to familiarize themselves with the plans for the desktop simulation.

4.1.2 Putting the Research Group Together

The size and composition of the research team depend very much on the size, type and complexity of the simulation exercise (Payne 1999: p. 116). The research team comprised of the staff members (12 staff members) of the African Centre for Disaster Studies-all researchers in the field of disaster risk management. All participants, including the research team were divided into the mentioned grouping (players, controllers, evaluators and observers) for the simulation and each had a different and specific role for the duration of the simulation.

4.2 Simulation and Data Collection

The exercise followed a process where the reactions of the participants to information was observed and adjustments made to the simulation according to decisions taken. Throughout the duration of the simulation, participants moved through a continuous process where, firstly, the scenario was presented, then the participants engage and react to the information, while observations were made and recorded. Consequently the scenario was adjusted to accommodate the reaction of the participants (Moats et al. 2008: p. 405–406). Data collection therefore became important not only for research purposes but was a integral component in giving the simulation exercise flexibility and ensuring that objectives of the simulation are realized.

Simulation time was stopped, paused or restarted whenever participants had questions that only the exercise controllers could answer, also if exercise issues arise and finally if participants' safety were compromised. The activity of pausing a simulation is in line with Payne's (1999: p. 116) suggestion that if something goes wrong in the simulation, activities should be suspended until all problems have been cleared up. The simulation exercise ended 3 hours after it started and was followed by a debriefing session.

4.3 Debriefing after Simulation

The final stage in the process of implementing SBT is debriefing (Moats et al. 2008: p. 405–406). A debriefing is the process of persons involved in specific experience having the opportunity of sharing what they have experienced by means of a "purposive discussion" (Moats et al. 2008: p. 405–406). According to Payne (1999: p. 116–117) careful evaluation should be done after such an exercise. The process of evaluation is very important for the learning experience and ensur-

ing that learning takes place (Moats et al. 2008). Documenting and compiling all outcomes of such an exercise in a report, further strengthens the learning experience. Payne (1999: p. 116–117) notes that there are various steps in the debriefing process, firstly what he calls a "hot wash-up". This is undertaken immediately after the simulation and participants have an opportunity to share their experiences. Payne (1999: p. 116–117) also proposes that there be separate debriefings held with each agency and their own staff. Finally, a meeting should be arranged with all key representatives from all agencies and findings from each agency are discussed and recommendations given on the way forward. Time should also be spent discussing the final report.

For this particular simulation, two debriefing sessions were held. The first involving all participating role-players and researchers. Specifically, one debriefing session was held directly after the simulation ended and it was facilitated by one of the controllers. This session was conducted systematically, but did not follow a very strict structure to allow people to express their experiences of the day. Some specific questions were posed to the participants who then had the opportunity to discuss their experiences. In this session comment cards were handed to all role-players as well as the research team to write down and capture their experiences and lessons learned.

The second debriefing was undertaken with the research team a few days after the simulation and time was spent on more practical issues surrounding the organizing of the simulation.

5 Findings and Recommendations

The observational research of the simulation exercise highlighted a number of findings and recommendations. These can be divided into two categories. Firstly, the research highlighted operation issues associated with the actual management of the scenario by the various response agencies, which in turn lead to learning and transformation (discussed later on in this section). Secondly, lessons learned by the research team in planning and executing a simulation exercise as an independent outside party will be discussed.

The most pertinent finding of the research was the obvious lack of coordination and common "language" amongst the various agencies. This exercise confirmed the perception that response agencies in South Africa still work in silos with minimal inter-agency coordination and understanding (despite a number of policies and legislation requiring the opposite). The lack of a common understanding of the management of an incident, specifically an unified incident

command system, was evident. Closely related to varying perceptions and application of incident command and management, the research found that there was a general false assumption with response agencies that all other agencies understood their roles and functions. This can be ascribed to the general deficiency in regular communication, joint planning and various levels of administrative functioning (e.g., local municipal, district municipality and provincial levels) by the various agencies. The assessments of existing contingency plans (where they existed) confirmed the gaps in planning and lack of alignment of plans. Mistrust and failed communication between agency commanders during the exercise, was a clear indication as to the need for better cooperation and fostering of understanding. The need for a strategic decision-making support system was identified. The exercise showed that tactical and operational decisions break down at some point if a strategic support system is absent. This finding has obvious linkages to a functioning incident command system, and clear roles and responsibilities delineation. Simulations should be as realistic as possible and contain many aspects of good theatre. This did not happen until the later part of the exercise. The reasons for the late theatrical reality during the simulation are many, but some prominent reasons relate to a familiarity with roles and responsibilities within agencies, the level of risk perception, and dread amongst participants to the simulation threat (spillage of ammonium diuranate). Another key finding was the need for a dedicated communications officer in multi-agency responses. The research identified the difficulties of the incident commander and/or agency commanders in dealing with the media, while also fulfilling their operation tasks. This lesson was seen by response agencies as quite significant because none of the existing policies and guideline to incident response make provision for this very important aspect.

Following the simulation exercise, the core response agencies heeded the above findings and a number of training interventions were organized (i.e., inter-agency communication and communication management, incident command training, and compiling of a job description for a communication/medial liaison officer). Subsequent research documented by Wiggill (2013) and Van Niekerk (2014b) shows the immediate benefit of these interventions. Lastly, the research found that incito improvisation occurred regularly amongst agencies (e.g., assuming communication channels which did not exist, assuming actions by fellow response agencies which did not occur [yet], or fabricating facts outside of the scenario script). This happened mostly because of the lack of information sharing or based on false assumptions of planning between the response agencies. Such *incito* improvisation proved a significant challenge for the exercise controllers who aimed to keep the simulation on script.

Beside the operational findings, the research also identified some methodological lessons which need to be taken into account when planning and executing simulation exercises. All role-players must be involved and briefed from the start. It is better to rather exclude an agency than have agencies participate in the exercise who do not fully understand the scenario. The lack of briefing all role-players significantly reduces the fidelity of the exercise, limits an understanding of the exercise rules, and contributes to a labor intensive management of the exercise by the controllers. It is thus crucial to place an emphasis on the roles and rules to be followed in planned simulation exercises by all role-players involved. From the perspective of the simulation controllers, more time can be spent during the planning phase to immerse the participants in the scenario. It was found that the "element of surprise" did not contribute at all to the better management of the scenario by response agencies. On the contrary, agencies not briefed on the simulation fared significantly worse that their counterparts. Better briefing of agencies, pre-exercise, allows role-players more time to visualize the event, and prepare mentally for their roles and actions once the simulation starts. External role-players, however, also have the important duty of familiarizing themselves with the simulation rules and role-player information guides before the exercise, in order for simulation effectiveness to be maximized. Clearer scripting will also ensure that key elements of the scenario will be addressed. The importance of utilizing multiple data collection sources to gain a holistic picture of important events that occur during a simulation became evident. During the simulation the use of observation guides, participant documents and video allowed for a great degree of data triangulation that could be referred back to when clarity was needed on some issues during the analysis of the data. Furthermore, debriefing should form a pivotal part of any simulation exercise. The debriefings allowed the simulation activity to be critiqued for strengths and weaknesses so that it may be improved and modified as necessary to be more realistic, challenging and valuable. A crucial aspect of the debriefing session was to document role-players' experiences and responses for further analyses. This allow for a number of central themes and lessons learned to emerge, which can be used to improve the quality and accuracy of future simulation exercises.

6 Conclusion

This article aimed to explain some of the practical and methodological lessons in the planning and execution of simulation exercises. A scenario of a hazardous material spill in an urban area in the Tlokwe Local Municipality, North-West

Province, South Africa was used as a case study. The research found that in the South African context attention needs to be paid to methodological and practical issues such as scenario development, role-player selection and involvement, fidelity during simulation delivery, data collection and participant (de) briefing.

References

Alexander, David (2000) "Scenario Methodology for Teaching Principles of Emergency Management," Disaster Prevention and Management, 9:89–97.

Bruinsma, Guido and Robert de Hoog (2006) "Exploring Protocols for Multidisciplinary Disaster Response using Adaptive Workflow Simulation," (paper presented at Proceedings of the 3rd International ISCRAM Conference Newark, NJ, USA, 14–17 May 2006).

Chi, Chih-Hsien, Wen-Hsin Chao, Chia-Chang Chuang, Ming-Che Tsai, and Liang-Miin Tsai (2001) "Emergency Medical Technicians' Disaster Training by Tabletop Exercise," The American Journal of Emergency Medicine, 19(5):433–7436.

Feinstein, A. H. and H. M. Cannon (2002) "Constructs of Simulation Evaluation," Simulation & Gaming, 33(4):425–440.

Green, Garry B., Surbri Modi, Keven Lunney, and Tamara L. Thomas (2003) "Generic Evaluation Methods for Disaster Drills in Developing Countries," Annals of Emergency Medicine, 41:689–699.

Hammond, Jeffery (2005) "Mass Causality Incidents: Planning Implications for Trauma Care," Scandinavian Journal of Surgery, 94:267–271.

Heumüller, Erich, Sebastian Richter, and Ulrike Lechner (2012) "Towards a Framework for Command Post Exercises." Proceedings of the 9th International ISCRAM Conference. Vancouver, April 1–6.

Issenberg, Barry, William Mcgaghie, Emil Petrusa, David Lee Gordon, and Ross Scalese (2005) "Features and Uses of High-Fidelity Medical Simulations That Lead to Effective Learning: a BEME Systematic Review," Medical Teacher 27(1):10–28.

Keene, S. Delane, Robert E. Solick, and James W. Lussier (1990) *Identification of Command Post Exercises (CPX) and Field Training Exercises (FTX) Messages.* U.S. Army Research Institute: Virginia.

Kincaid, Peter J., Joseph Donovan, and Beth Pettitt (2003) "Simulation Techniques for Training Emergency Response," International Journal of Emergency Management, 1:238–246.

Kleiboer, Marieke (1997) "Simulation Methodology for Crisis Management Support," Journal of Contingencies and Crisis Management, 5:198–206.

Moats, Jason B., Thomas J. Chermack, and Larry M. Dooley (2008) "Using Scenarios to Develop Crisis Managers: Applications of Scenario Planning and Scenario-Based Training," Advances in Developing Human Resources, 10:397.

Olson, D. K., M. M. Hoeppner, K. Scaletta, M. Peck, and R. Newkirk (2012) "Games, Simulations, and Learning in Emergency Preparedness: a Review of the Literature," American Journal of Disaster Medicine, 7(2):145–154.

Paton, Douglas and Rhona Flin (1999) "Disaster Stress: an Emergency Management Perspective," Disaster Prevention and Management, 8:261–267.

Paton, Douglas and Duncan Jackson (2002) "Developing Disaster Management Capability: an Assessment Centre Approach," Disaster Prevention and Management, 11:115–122.
Payne, Christopher F. (1999) "Contingency Plan Exercises," Disaster Prevention and Management, 8:111–117.
Pelling, Mark and Ailsa Jane Holloway (2006) *Legislation for Mainstreaming Disaster Risk Reduction*. Tearfund, Teddington: Tearfund.
Renda-Tanali, Irmak and Husein Abdul-Hamid (2011) "An Assessment of the Benefits of Online Scenario Simulation Tools in Homeland Security and Emergency Management Education," Journal of Homeland Security and Emergency Management, 8(2):1–16.
Schoemaker, Paul J. H. (1993) "Multiple Scenario Development: Its Conceptual and Behavioral Foundation," Strategic Management Journal, 14(3) Wiley online Library:193–213.
Smith, Walter, John Dowel, and M A. Ortega-Lafuente (1999) "Designing Paper Disasters: An Authoring Environment for Developing Training Exercises in Integrated Emergency Management," Cognition, Technology & Work, 1:119–131.
Van Niekerk, Dewald (2014a) "A Critical Analysis of the South African Disaster Risk Management Policy and Legislation," Disasters, 38(4):858–77.
Van Niekerk, Dewald (2014b) "From Burning to Learning: Adaptive Management to Wildfires in the North-West Province of South Africa," Journal of Human Ecology (in press).
Wack, Pierre (1985) "Scenarios: Uncharted Waters Ahead," Harvard Business Review (Sept–Oct):73–89.
Wagner, Neal and Vikas Agrawal (2014) "Expert Systems with Applications," Expert Systems with Applications, 41(6):2807–2815.
Wiggill, Magrita N. (2013) "Communication Management During the Veld Fires of 23 August 2011 in the Tlokwe Local Municipality: a Cautionary Tale," Jàmbá: Journal of Disaster Risk Studies, 5(2):1–9.
Wilkerson William, Dan Avstreih, Larry Grupen, Klaus-Peter Beier, and James Woolliscroft (2008) "Using Immersive Simulation for Training First Responders for Mass Casualty Incidents," Academic Emergency Management, 15:1152–1159.
Zegras, Christopher and Lisa Rayle (2012) "Testing the Rhetoric: an Approach to Assess Scenario Planning's Role as a Catalyst for Urban Policy Integration," Futures, 44(4):303–318.