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Scenario development for the Evaluation of Command and control tools –Implementation test of a Flying Localization System

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Abstract: The TH Köln - University of Applied Sciences has developed a flying localization system for the detection of buried victims after building collapses. An important task of the TH Kölnis to validate the technical capabilities of the developed system as well as its efficient implementation in the command and control structures of first responders. The objective of the present study was the development of suitable scenarios to evaluate the technical system and its implementation during laboratory scale and large-scale rescue exercises. In order to develop capable scenarios, relevant national as well as international first responder organizations and their requirements for such a scenario were identified. Furthermore, the requirements of the localization system were taken into account to ensure the evaluability of the technical system. To develop a realistic and representative scenario, real collapse events were additionally investigated and statistically analyzed.With the completion of the study, one representative national and one representative international collapse event, based on the identified requirements and an average collapse incident, were developed. The results of the tabletop exercise have shown that suitable scenarios were chosen and that the implementation of the system is appropriate.

Keywords: Unmanned Aerial Vehicle; Scenario Development; Emergency Exercise; Exercise Evaluation

I. INTRODUCTION

There are several incidents that cause building collapses worldwide. Earthquakes, gas explosions or similar events lead to many trapped victims that need to be found quickly. For example, the Swiss Re Institute classified 16 earthquakes as catastrophes in 2016[1]. In Ecuador, 673 people died during an earthquake on April 16thand on August 24th, 299 people died in Italyduring a similar event[1, 2].

With these events in mind, the aim of the research project FOUNT^{2}was the development of a flying victim localization system that supports urban search and rescue (USAR) teams and enhances their safety during their emergency response. The FOUNT^2-system consists of an unmanned aerial vehicle (UAV) equipped with an autonomous landing site detection and a bioradar that is used to detect the breathing movements of buried people under the debris. Important elements of the project were the optimization of the flight time, the load capacity of the UAV and furthermore, reducing the size as well as the weight of the bioradar. In addition, the system is supplemented by a user interface for mission planning and the control of the UAV. Moreover, the implementation of the FOUNT^2-system in national and international command and control structures as well as the adaption of the information processes was part of the research project [3].

An important part of the research project was the evaluation of the technical system as well as validation of the successful implementation of this system in the command and control structures. This evaluation and validation required tabletop exercises and large-scale exercises for which a suitable scenario needed to be developed initially. How these scenarios can be scientifically developed is not only an essential foundation for the described project, but also for the future validation of new incident command technologies.

II. PROBLEM IDENTIFICATION AND BASIC PRINCIPLES

The ongoing development of command and control systems can be noted in all areas.The widely used and often adaptedNational Incident Management System(NIMS)from the USA has just recently been adapted and revised[4].In addition, standardization committees deal with the preparation of standards that address an international harmonization of incident management[5, 6]. In this way, it can be ensured that even cross-border catastrophes can be dealt with in close cross-organisational and cross-functional work.It is essential to evaluate adaptations and new features of these systems in order to receive early and scenario-based feedback of the changes.A negative feedback in a real incidentcan be a painful experience with loss of property and even loss of life.Testing the new system during a real incident without any experience would be difficult and too dangerous [7].

If the German incident command system for emergency operations (FwDV 100) is considered, the UAV developed in the FOUNT^2 research project can also be regarded as an adaptation of the command and control system.The FwDV 100 divides the command system into three different components: Command Organization, Command and control Process, as well as Means to implement the incident command (Fig. 1). [8]

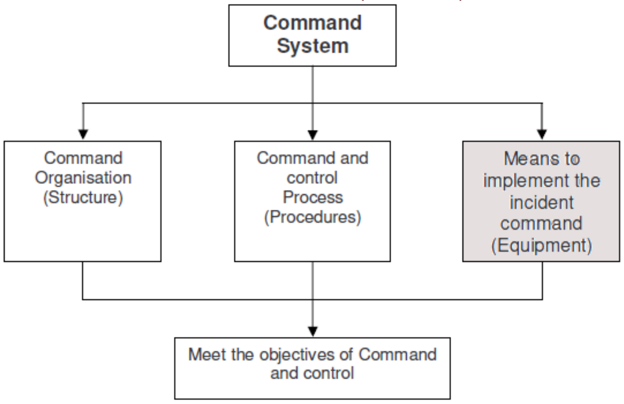

Fig. 1 Command System of the FwDV 100 [8]

The developed UAV can be seen as a new means for the implementation of the incident command.In more detail, it can be seen as a way togather information, which can be applied during the first phase of the command and control process(establishing situation) (Fig.2).

If the UAV meets the necessary technical requirements for a rapid search for victims after a collapse event and if it is properly integrated into the command and control structures, it can be an important tool for gathering information in situations such as these. This type of equipment can significantly shorten the first stage of the command process and the execution of rescue measures can therefore begin earlier.

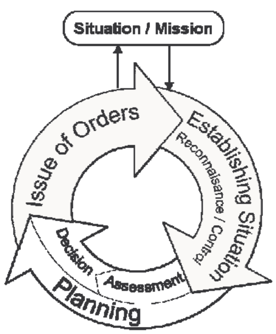

Fig. 2 Circular chart of the command process of the FwDV 100 [8]

To determine whether both requirement scopes are met, the technical and the implementation requirements must be carefully tested with scenario-based evaluation and validation. The fundament of this evaluation method is based on the development of a suitable scenario. How the scientific scenario development was carried out and how it can be used is shown in this paper.

III. METHODOLOGY

The method includes several identification and analysis steps, which were merged in thescenario selection step. A summarizing flowchart of the method can be seen in Fig 3.

Regarding the development of scenarios that meet the requirements of each involved organization and the technology in use, at first the acting players had to be identified. Due to differences in the acting organizations involved in a collapse event, which are based on the location and the incident size, a distinction was made between German and international incident management. In order to identify all relevant organizations working at the scene of a collapse incident in the area of Germany, the German Fire Protection Association(GFPA) guideline 03/01 was analysed.

A similar analysis was carried out to identify the stakeholders who are active on an international scaleinlarge-scale collapse incidents. For example, earthquakes in urban regions, in which local response teams are unabke to adequately cope. The main sources used for this analysis were the International Search and Rescue Advisory Group (INSARAG) guidelines because of the great significance of these regulations during past international urban search and rescue operations [9, 10, 11, 12, 13].

The following step identifies the requirements of the previously detected players with focus on the design of an adapted and beneficial scenario that meets the exercise objectives of the relevant organization. It must be considered that every type of actor (e.g.,firefighters, medical personnel, police officers) in the process of emergency response requires a different form of training [14]and every group of actors has specific requirements for the training scenario. For this purpose, the already mentioned regulations (GFPA 03/01, INSARAG guidelines) and several training requirements (United Nations Office for the Coordination of Humanitarian Affairs, 2015d)were analysed after the different operational periods and the corresponding tasks that the identified players have to execute.

Furthermore, the scenario was applied to the evaluation of a technical device (UAV), which makes necessary the recognition of adaptions of the scenario for the purpose of exact technical testing. These adaptions can be derived from the requirements statement of the technical device, which is based in this particular case on a workshop carried out at the authors university in February 2017. The workshop addressed the topics of technical, functional and tactical requirements of the FOUNT^2-system, which were developed by 40 experts from the fields of emergency response, urban search and rescue, research of civil protection as well as UAV development in different workgroups. The findings about the organizational and technical requirements are incorporated in the later selection of an appropriate scenario.

Beside the selection of the scenario with focus on the training requirements of the different organizations and the evaluating possibilities of a technical device, the scenario has to be realistic and relevant. The use of a realistic scenario is ensured by selecting a real event that occurred as a model for the adapted scenario. The relevance was based on the selection of a real event that contains the average circumstances of a collapse incident in urban areas. In order to identify the representative collapse incident, a large number of relevant events with collapsed buildings was recorded and analyzed according to the building type, construction and utilization as well as the debris structure of the collapsed building. Since the scenario must have at least one victim buried alive to meet the urban search and rescue requirement, the collapsed structure has to contain possible spaces for survival. These spaces were identified in each recorded collapse event by the application of the scheme “Systematics of the debris area” developed by Maack and updated by Gehbauer et al. [15, 16, 17, 18]

The number of occurred collapse events can be reduced to a few scenarios by creating a relevant as well as a representative scenario and by considering all organizational and technical requirements. The remaining collapse events providea good foundation to select a scenario thatrepresents a realistic and frequently happening event. Therefore, the authors used a rating system that included weighting the requirements' priorities:A high priority was given to all requirements that are absolute necessary for a successful application of the FOUNT^2-system;a medium priority for requirements that are necessary for USAR processes; and a low priority for requirements that are not absolutely required. In total, 44 requirements were identified; however, requirements that are totally independent of the scenario were removed. By considering the 22 remaining and weighted requirements on the remaining events, it is possible to choose the most appropriate collapse event as a model for the exercise scenario.

Before carrying out a large-scale exercise, the selected scenario first needs to be tested in a laboratory scale exercise.These kind of exercises are also called tabletop exercises.In addition, they serve as a first validation of the tactical implementation of the considered system. The advantage of this kind of exercise is in particular the inexpensive feasibility in contrast to large-scale exercises.

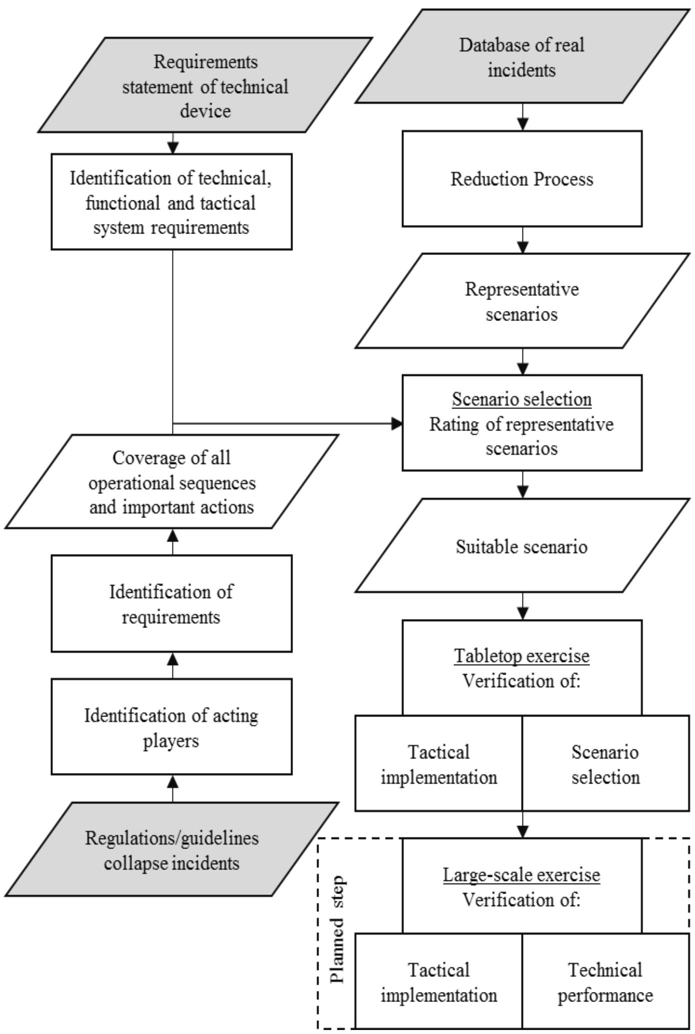

Fig. 3: Flowchart of the overall method

IV. RESULTS AND DISCUSSIONS

At the beginning of the analysis, built on the results of a preceding research project, 46 events were added to the database of collapse incidents from the year 2013 onwards. Because of the small number of events for which data is available, the results were compared with results of other research projects [15]. After filtering out rare events and those, which did not show possible spaces for surviving victims, the large number of incidents was reduced to nine incidents, which are listed in table 1. For the international scenario, the three listed earthquakes are the best match, while for the national scenario; the gas explosion in Dortmund (Germany) is the best result.

Table 1: Results of the reduction process

Real incident	Percentage match to the requirements
Earthquake in Kathmandu (Nepal), 25 April 2015	90
Earthquake in Musine (Ecuador), 16 April 2016	90
Earthquake in Pescara del Tronto (Italy), 24 August 2016	90
Gas explosion in Dortmund (Germany), 31 March 2017	82.5
Gas explosion in Gladenbach (Germany), 15 December 2014	77.5
Gas explosion in New York (USA), 26 March 2015	77.5
Gas explosion in Swiebodzice (Poland), 8 April 2017	77.5
Gas explosion in New York (USA), 12 March 2014	67.5
Gas explosion in Wolgograd (Russia), 16 May 2017	65

The further consideration of these incidents by comparing the details of the real incidents, resulted in two particularly suitable scenarios.

The incident used as model for "Scenario 1" occurred on 31 March 2017: a gas explosion in the city of Dortmund, Germany. A four-story building partially collapsed and with one missing victim, whowas later found dead. The collapsed part of the residential building indicated various possible spaces for surviving buried victims.

The incident used as model for "Scenario 2", which happened on 24 August 2016: an earthquake in central Italy. The earthquake had an impact on at least 2.000 people; 299 were buried under collapsed buildings and 368 were injured. It did not make sense to use the entire affected area for the scenario model because such a scenario scale is not feasible for an incident exercise. As an alternative, one specific incident site in the disaster area was selected. In this specific case, the authors selected a partially collapsed building in the village Pescara del Tronto, because it showed possible spaces for survival as well as a typical damage structure of collapsed buildings, which were affected by the earthquake.

For a clear summary of the most important facts about the two selected scenarios, basic information such as location, weather, surroundings, victims and debris structure were listed in a scenario chart. This chart provides a good basis for planning the exercise in more detail.

Scenario 1 was already carried out in a tabletop exercise at TH Köln and consequently, the first results of the validation could already be achieved. The participants'(all from first responder organizations) feedback showed that the selected scenario was suitable and further evaluations have shown that the implementation of the system into the existing command and control structures is appropriate.

V. DISCUSSION

By using real incidents as models for the scenario development, the scenarios achieve a high level of plausibility, because they already occurred in the past and they provide accurate information for the design of the scenario [7]. Furthermore, the analysis of the past events demonstrates which kind of incident occurred most frequently. The knowledge about the most relevant and representative scenarios makes it possible to choose a scenario model, which prepares the USAR teams as well as the technical equipment most efficient for the deployments in a real emergency event. For sure it is important to note that a large number of unexpected events can occur in the real-world operations. Therefore, the present method only can prepare for the most foreseeable events.

In addition, it must be considered that the authors focused on the organizational requirements of German first responders and the INSARAG certified USAR teams. On the one hand, this main focus provides a good overview about the requirements of a small-scale scenario in the area of Germany and a large-scale scenario in the context of an international response.On the other hand, it is obvious that many organizational requirements of coexisting USAR organizations could not be taken into account.

CONCLUSIONS

The developed method is a useful tool for scenario development and the evaluation of incident command tools based on it. However, large-scale exerciseshave to be carried out to obtain further information about the quality of the shown scenario development. In particular, the technical performance of the UAV could not be observed by the results of the tabletop exercise.

Abbreviations

FwDV	German incident command system for emergency operations
GFPA	German Fire Protection Association
INSARAG	International Search and Rescue Advisory Group
NIMS	National Incident Management System
USAR	Urban Search and Rescue

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