Collaborative Authoring of Virtual Simulation Scenarios for Assessing Situational Awareness

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ABSTRACT

Situational awareness (SA), the ability to perceive, comprehend and predict situation around you and it is a key in attending any incident as critical foundation for successful decision-making. Because incidents are solitary events, development and assessment of SA presents a significant challenge. In this article we analyze the authoring process of twenty-two scenarios implemented in the XVR on-scene virtual simulation software used to assess rescue incident commanders' (ICs) SA. To allow the scenarios to be used by different assessors, *the Collaborative Authoring Process Model for Virtual Simulation Scenarios* (CAPM) was developed. In Estonia, 473 assessments were recorded in Effective Command database and analysed by all three levels of SA as recommended by Endsley (2000). Introduction of CAPM resulted in scenarios being re-used by different assessors for authentic SA measuring. In the last sections of this article, we introduce our suggestions to improve virtual scenario design and SA research.

Keywords

Situational awareness (SA), virtual simulation, virtual simulation scenario, process model, effective command behavioral marker framework.

INTRODUCTION

Situational awareness (SA) is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". The construct, thus, combines three levels: SA Level 1 perception, SA Level 2 comprehension, and SA Level 3 prediction (Endsley, 2000). SA is the foundation of dynamic decision-making (DDM) to execute command and control activities. Even if the "elements" of SA vary widely between domains, it can be characterized the same way (Endsley, 2000). Researchers seem to agree that to train and assess SA, virtual simulations could be used (Lukosch, van Ruijven, & Verbraeck, 2012). Moreover, the use of simulations to train and assess SA is a well-known practice in training pilots (Endsley, 1995) and rescue incident commanders (ICs) (Polikarpus, Ley, & Poom-Valickis, 2020). However, the use of virtual simulations for training SA (Polikarpus et al., 2020) and assessment of SA is still an open research topic (Edgar et al., 2018).

SA training requires immersive and meaningful virtual training environment (Lukosch et al., 2012). Such environments often require co-operation with programmers. Duval and colleagues studied the use of participatory game design approach by non-experts highlighting two dimensions for virtual simulation scenario design: the pedagogy – the feedback that the learner receives in the virtual environment during a training session; and the procedure – modeling the learners activities in the simulation itself (Duval et al., 2015). The study did not, however, explain how to execute that for example, in XVR On-Scene (XVR OS) software. A study by Reis and

Neves (2019) concluded that training activities using Effective Command Behavioral Marker Framework – the pedagogy dimension – seem adequate to develop ICs DDM. However, they state that further studies are needed to improve the virtual scenarios (Reis & Neves, 2019), the procedure dimension implemented in XVR OS.

The appropriate training tool for SA should have high functional and physical fidelity, a high degree of realism, and challenging elements in the scenario to give a meaningful experience for participants within an authentic virtual training environment (Lukosch et al., 2012). Creating scenarios for a virtual simulation platform is a time-consuming task (Wijkmark & Heldal, 2020). Unfortunately, the implementation process of virtual simulations for training emergency personnel could have several obstacles, such as a skeptical attitude towards the use of virtual simulations or insufficient trainer competence, or a mismatch of expectations concerning learning outcomes (Heldal & Wijkmark, 2017). Collaboration of experts from different disciplines in the design of these scenarios can increase their acceptance and effectiveness (Leoste, Tammets, & Ley, 2019). Heldal and Wijkmark (2017) also find that the virtual simulation building process has to be adjusted to local needs. In order to enable all trainers in an organization to share and use the virtual simulation scenarios, the process of implementing virtual simulation-based training in organizations should be documented, but it very seldom is.

To our best knowledge, no process model has so far been documented that would facilitate the systematic creation of scenarios by different assessors in a practical setting for authentic IC SA assessment. To address some of these problems and eliminate, or shorten, this gap, we propose the *Collaborative Authoring Process Model for Virtual Simulation Scenarios* (CAPM). The model has three key characteristics:

- it is a practically feasible and tested method that allows scenarios to be used in authentic settings of training organizations;
- it is a collaborative process model which involves trainer teams in the creation of scenarios for scaling up in the organization and increasing acceptance;
- it allows including situational elements in virtual simulation that are critical for SA training and assessment.

This article reports on the implementation of CAPM in the context of rescue incident commanders SA training and assessment in Estonia. We present an evaluation that highlights how the implementation of the method allowed us to include situational elements into the scenarios used for assessing SA. We also discuss some further steps to improve SA scenario building and assessment in the future.

CO-AUTHORING OF VIRTUAL SIMULATION SCENARIOS

The aim of the development project in the Estonian Academy of Security Sciences (EASS) was sustainable implementation of Effective Command while using XVR OS software (Polikarpus, 2019). The key-element in the project was to bring virtual simulation software users together so they could support and learn from each other. In table 1, the steps and activities of designing virtual simulation scenarios are described. Five scenario-building steps were jointly agreed among certified Effective Command assessors, who could also build scenarios in XVR OS. Both authors should have knowledge of incident command and Effective Command framework. To make a clear distinction between different tasks, we used metaphors from film production. In table 1 the "producer", is the person with XVR OS programming skills and the other author is referred to as "scriptwriter" to tell the story of the scenario.

In the first phase of CAPM, the virtual scenario map is drafted. The map is necessary for introducing the assessment scenario idea in the organization in order to make budget decisions and contracts with the authors. *The virtual scenario map* is an A4 Microsoft Excel spreadsheet with different questions asked from authors to draw them to consider different aspects of the scenario. These aspects include an abstract of the storyline; learning goals/main dilemmas; risks of the scenario build and use; SA; plan; review; other information. To make sure the storyline idea is feasible, the scenario map includes the first screenshot from XVR OS, where most important 3D objects and elements are presented. The scriptwriter starts to draft *the scenario´s user manual* and the producer starts building the XVR OS file.

During the second step of CAPM, it is important for the co-authors to develop the storyline further. Co-authoring helps to think about the pedagogy and the procedure dimensions (Duval et al., 2015). The storyline must allow the implementation of DDM model for SA assessment. For example, it could start with information about a traffic accident, where a car drove off the road. The next piece of information given to the IC is that the vehicle may fall into a river. Then information about hazardous materials truck is presented and so on. This kind of story creates dilemmas for IC and as does the lack of resources to deal with all threats at once. So, the IC makes an initial plan to deal with the incident, but then updates his/her SA during the response and modifies the plan to deal with other threats that were presented later in the storyline.

Table 1. The Collaborative Authoring Process Model for Virtual Simulation Scenarios (CAPM)

Steps	Sub-activities	Producer activities	Scriptwriter activities
1. Writing the ICs virtual scenario map.	• Finding a co-author • Writing ICs scenario map • Choosing XVR environment and important 3D elements	Finds the XVR environment and essential 3D objects.	Writes the scenario map.
2. Scenario authoring according to the EASS virtual scenario building guideline. Building starts from static environment visualization where dynamic elements are added that introduce situational changes.	• Building in XVR OS • Discussions between authors to find relevant situational elements for storyline to be suitable for implementation of DDM model.	Builds the scenario in XVR OS. Merging already existing situational elements like template files and favourite objects.	Describes in the user manual storyline.
3. Virtual simulation scenario technical testing: reviewed by others who have same competences as authors.	• Dynamic play-through of the scenario • Discussion based on three criteria (see below) • Threshold play-through agreement	Plays the scenario as technical author in dynamic phase.	Plays the scenario as author who does voices to avatars in dynamic phase.
4. Finalizing the virtual scenario by fixing unclear points in scenario user manual and/or XVR OS file.	• Amendments in XVR OS file and user manual based on technical play-through • Adding missing elements agreed in technical testing	Makes amendments in XVR OS file.	Makes amendments in scenario user manual and adds expected threshold response.
5. Modelling the threshold play-through for the scenario to all assessors.	• Dynamic threshold play-through • Assessment debrief discussion and filling in the certificates • Comparison of assessment criteria • Agreements for different tactical approaches	Plays the scenario as technical author in dynamic phase of assessment.	Plays the scenario as author who does voices to avatars in dynamic phase of assessment.

All assessment scenarios are built according to *the EASS virtual scenario building guideline*. The guideline is a checklist of non-dynamic (3D objects like hazmat truck labelling) and dynamic (like fire, leak etc.) situational elements to help producers to use them consistent ways in XVR OS to visualize the storyline and trainees' activities. For example, in the guideline it is stated that all 3D objects added to the scenario that do not need to be moved during the play should be disabled. The objects that might be moved by responders, like cars, victims etc. need to be locked. All resources available for IC need to be added etc. Template file for first level ICs minimum resources needs to be merged, meaning at least three fire pumps with teams, one police vehicle, one ambulance and their crews are merged into scenario. Events should be used for dynamic elements that does not depend on ICs` decisions (like certain kind of fire spread in building, arriving of resources etc.).

The third step of CAPM requires the technical testing of the virtual simulation scenario. The step appears when co-authors have reached the point that they feel the scenario user manual and XVR OS file are ready. The authors of the scenario present their work to two other equally qualified colleagues in EASS. Three criteria are checked during the technical testing phase:

a) Understandability of visual and audio inputs to non-authors;

b) Credibility of the story and

c) Evaluation of the use of the EASS virtual scenario building guideline.

To allow a fresh look at the scenario, it is played through by a person who has not seen the visual in XVR OS or heard the story before. After the dynamic play-through, the earlier named three criteria are discussed in a group of four assessors. It is jointly agreed what changes in the story and files are made. At the end of technical testing, the ICs threshold of the scenario is agreed. Threshold for required rescue activities are added to user manual. The threshold (expressed with yellow colour in certificate, see explanation below) must be in accordance with ICs vocational occupation qualification standard.

In step four of CAPM, the authors finalize the virtual scenario by making the final changes in the storyline. Agreed changes are written down in the scenario user manual and made in XVR OS file.

The fifth and last CAPM step is modelling the threshold play-through for the scenario, and in this step, the new assessment scenario is introduced to all certified Effective Command assessors in the EASS. The storyline from user manual and XVR OS file is presented and the dynamic play of the scenario is done on previously agreed threshold level. The co-authors of the scenario act as assessors. After dynamic assessment phase the feedforward assessment dialog is carried out by co-authors and ICs role-player. Then co-authors fill in one certificate and all other assessors fill individually in the certificates. All eight DDM assessment blocks in Effective Command and nine criteria in each block are compared with authors certificate and discussed. Other possible tactical solutions to the incident, and the assessment of these solutions are discussed.

TRAINING AND ASSESSMENT OF DECISION-MAKING AND SITUATIONAL AWARENESS IN ESTONIA

Estonia is a country in the European Union with a population of 1,3 million and it has state funded centralized rescue service authority. There are around 350 first level ICs, who work in 24/7 shifts in 72 fire stations all over the country. All first level ICs´ vocational education is carried out in EASS Rescue College. To work as a first level IC, Rescue unit leader level 5 occupational qualification certificate is required.

Implementation of Effective Command (Lamb, Farrow, Olymbios, Launder, & Greatbatch, 2020) started in 2016 during the obligatory training and assessment day as part of work attestation for all first level ICs in Estonia (Polikarpus et al., 2020). During the day, Effective Command is used to assess DDM skills as well as measure ICs SA levels (Lamb et al., 2020). The named framework is based on a DDM model. Here, however, we focus only on SA assessment using virtual simulation scenarios.

At the end of the training and assessment day, two certified assessors fill in the Effective Command web-based form using coloured scoring for each of the DDM five key-behaviours. The SA has three subsections for each level – perception, comprehension, and prediction. All subsections in Effective Command are measured with nine assessment criteria on the five-point coloured scale. The scoring of section can be between 20 to 100 points. Excellent subsection result meaning green colour is given when 70 points in a subsection is received, and yellow result meaning threshold is above 55,5 points. Score below 55,5 points is seen as fail and marked with red colour. (Lamb et al., 2020) Recorded SA formal assessment results allowed us to study the implementation of CAPM in organization.

EVALUATION OF CAPM

This research followed evaluation research paradigm where we employed a mix of qualitative and quantitative analyses to evaluate the implementation of the CAPM. The overall research strategy here was to employ data on previous applications of the SA assessments using Effective Command framework to derive data-informed decisions on the further development of virtual simulation scenarios for SA assessments.

To accomplish our aim to evaluate a process model for co-authoring virtual simulation scenarios for ICs authentic SA assessment in an organization, two research questions were introduced to be answered based on the data we had from the development project and formal assessment results.

- RQ1: What are the situational elements for assessing ICs SA within scenarios in an authentic virtual training environment?
- RQ2: How can the consistency of the SA scores be increased?

During the development project team meetings, agreements concerning the authoring virtual simulations were documented. We analysed content generated from team meetings and the scenario user manual for a qualitative research focus. For the quantitative analysis, we collected a dataset consisting of 473 formal first level working ICs` attestation. The dataset was a result of assessments conducted using Effective Command for SA assessments implemented on XVR OS. All virtual simulation scenarios were built using XVR OS software and used for first level ICs formal DDM assessments during the training and assessment days (see more details in the background chapter). Effective Command using DDM and XVR OS is seen a reliable way to measure all three SA levels (Polikarpus et al., 2020). All formal assessments were carried out by two certified assessors and uploaded to Effective Command database. Assessment results from 2017 to February 2020 were downloaded from database on 28.02.2020. The dataset included 22 different scenario codes uniquely designed for each scenario. Ten scenarios were created before the co-authoring and twelve using CAPM.

To answer the first research question, we analysed project meeting minutes, scenario user manual, and descriptive statistics in Microsoft Excel. We used the following variables from Effective Command database: IC´s IDnumber; scenario code; SA level 1 perception score; SA level 2 comprehension score; SA level 3 prediction score.

To answer the second research question, we analysed the IC SA levels score differences in relation to the scenario and its storyline. We used scenario user manuals and the previously mentioned variables from Effective Command database. Using Microsoft Excel, we found out how many times each scenario has been used and calculated the mean scores for the whole dataset as well for each scenario SA levels.

RESULTS

Over the years 2016-2019 there were eleven authors and twenty-two virtual scenarios built on XVR OS.

The Situational Elements of Virtual Simulation Scenario

To answer the question concerning the situational elements for assessing ICs SA within scenarios, we analysed twenty-two scenario user manuals and meeting minutes.

One scenario (TM118) out of twenty-two was used fifty-five times and four of them (JM118; LK118; RT118; AS118) more than forty times (see table 1 column Used). In contrast, four scenarios were used only once in official ICs work-attestation in years 2017-2020. All virtual scenarios involved casualties to be rescued. The number of victims varied from two severely injured victims in traffic accident (SCRAC15) to multiple victims during a fire in a festival area (AT118) (see table 2 column Victim). Fire was used eighteen times in some point in the storyline (see table 2 column Fire) to create dilemmas for incident commanders. Another element to create dynamic situation change for measuring the SA criteria is hazardous material leak (used 9 times) as seen column Leak. Risks and issues from traffic were used ten times (see table 2 column Traf.).

Table 2. The scenarios used for SA assessments

No	Name	Code	Used	Year/ CAPM	Victim	Fire	Leak	Traf.
1	Bus and train collision	TR119	1	2020/1	yes	no	no	yes
2	Car fire in gas station	AB15_2	1	2016/0	yes	yes	yes	yes
3	Fire in industrial building	IE15_4	1	2016/0	yes	yes	no	no
4	Diesel leak from truck on highway	DCM15_5	1	2016/0	yes	no	yes	yes
5	Facade fire in office building	AB15_7	4	2016/0	yes	yes	no	no
6	Collapse of a building due to snow	TM318	7	2018/1	yes	no	yes	no
7	Bus and gasoline truck accident	AT119	12	2019/1	yes	yes	yes	yes
8	Apartment fire	AB15_8	12	2016/0	yes	yes	no	no
9	Garage fire in apartment building	AB15_10	12	2016/0	yes	yes	no	no
10	Suicide from gunshot and fire	JM218	18	2018/1	yes	yes	no	no
11	Abounded semi-detached house fire	SMH_11	19	2017/0	yes	yes	no	no
12	Under construction building fire	TR218	20	2018/1	yes	yes	no	no
13	Car crash, electrical substation fire	TM218	21	2018/1	yes	yes	no	yes
14	Gas fire in pet shop	SMH15_9	25	2016/0	yes	yes	yes	no
15	Hazmat truck accident	SCRAC15	28	2017/0	yes	no	yes	yes
16	Tent fire in festival area	AT118	29	2018/1	yes	yes	no	yes
17	Traffic accident with elk	3LM16	29	2017/0	yes	yes	no	yes
18	Industrial building roof fire	JM118	40	2018/1	yes	yes	yes	no
19	Truck between gate	LK118	44	2018/1	yes	yes	yes	yes
20	Gas explosion and fire	RT118	46	2018/1	yes	yes	yes	no
21	Fire in liquor store	AS118	48	2018/1	yes	yes	no	no
22	Truck - loader collision, fire	TM118	55	2018/1	yes	yes	no	yes
		Total	**473**	**CAPM: 12**	**22**	**18**	**9**	**10**

To summarize, the most popular situational element in scenarios is victims to be rescued. This element was followed by fire (see Table 2) as scenarios with fire were used 430 times for formal SA assessments. In a storyline the leak (see Table 2) was used 195 times. Scenarios with traffic element (see Table 2 column Traf.) were used 218 times. Scenarios with fire but no leak or traffic elements (for example TR218 and AS118) included were implemented 129 times. Scenario with fire and issues from traffic but no leak (for example AT118 and 3LM16) were solved 134 times. One scenario (SCRAC15) out of sixteen (used 28 times) has no fire, but has leak and traffic included. Finally, scenarios LK118 and AT119 that involved all four analysed elements (victim, fire, leak, traffic) were used 56 times.

The reasons for some scenarios being used only once in the dataset are that it is a new scenario, not used yet (TR119; TM318); it is an assessment scenario changed to training scenario (AB15_2); it was used a lot already in 2016 (IE15_4); or the scenario was found to be not well aligned with the DDM model (DCM15_5). As high-rise buildings are not common in Estonia, the scenario (AB15_7) was only used 4 times, because it is not a probable accident type to most of ICs in Estonia and the skills required to solve it are above occupational qualification standard. In Table 3 we summarize the qualitative reasons for continued use and discontinued use of scenarios.

Table 3. Reasons for continued use and discontinued use of virtual simulation scenario

Reasons for continuing the use of virtual simulation scenario	Reasons for discontinuing the use of virtual simulation scenario
• Storyline fits local circumstances • In accordance with the theoretical model of SA and DDM • Technically easy to use in XVR OS • XVR OS updates allowing better visualization	• Storyline fits only urban locations ICs • Too few dynamic changes in storyline to assess DDM • Overused scenario with a risk of being already familiar to ICs

The XVR OS software updates have also inspired technical changes of visualizing some elements in scenarios. For example, leaks could be animated. It is worth mentioning that XVR control center was changed significantly in 2018. That change required the update of the EASS virtual scenario building guideline concerning how different elements in the storyline need to be visualized for ICs. However, the process steps in CAPM to design, build, introduce, and implement the new scenarios into organization remained workable (see Table 1) and did not need to be updated. Effective Command web-based tool changed in year 2017 and that is the reason why formal assessment results from year 2016 were not included to the study.

The fact that twelve scenarios were built using CAPM and used by different assessors indicates that CAPM is useful for the re-use of virtual scenarios between different assessors. However, it should be considered that the CAPM was developed during the same time as the virtual scenarios were built and used. Therefore, it is impossible to distinguish if the model influenced scenario building and SA assessment results or it was the other way around. The assessors' experiences during the assessments influenced the CAPM and its implementation for virtual scenario built in XVR OS. Because virtual simulations were created by non-experts who gained expertise during the building and using of virtual simulations we consider that as the strength of the process model. There were four situational elements in scenarios to assess ICs SA in dynamically changing incident: casualties, fire, leaks and traffic issues.

The Influence of Situational Elements on The Consistency of Situational Awareness Scores

The second research question concerned ways of increasing the consistency of the SA scores. To answer this, we used descriptive statistics for the scores of ten scenarios implemented 333 times. These scenarios were built using CAPM and used more than ten times for assessments.

Table 4 presents the average scores (means) and standard deviations (SD) of ten assessment scenario SA levels scores. The average of SA level 1 score is 66.70 and SD is 7.20 for these ten scenarios. SA level 2 is 65.85 (SD 7.89) and SA level 3 is 63.68 with highest SD 8.51. In all ten cases SA levels perception and prediction score means differ from each other, meaning that perception is better than prediction (see Table 4). In table 4 is seen that four cases (TR218; JM218; RT118 and TM118) SA level 1 score is below average, three cases (TR218; JM218; RT118) SA level 2 is below average and four cases is SA level 3 below average (TR218; JM218; RT118 and AS118).

We studied the inconsistency in SA scores relating to scenarios (see Table 4 blue coloured cells). In two scenarios (JM218 and TM218) the average SA level 2 comprehension was higher than level 3 prediction (see Table 4 column Diff SA2, SA3). The storyline (JM 218) might be difficult for ICs to understand the development of the fire inside the building because the person, who later shot himself, first purposefully set his house into fire. This finding from data analyses shall be used during the reflective discussion phase with ICs. For car crash, electrical substation fire (TM218) the difference between SA level 3 prediction and SA level 2 comprehension is small (used 21 times and 0,1 points). However, the scenario storyline is interesting as the traffic accident causes the fire in the electrical substation because of damaged electricity pole and wires. Fire in electrical substation requires a specific response and that should be practiced.

Table 4. SA mean scores and standard deviations

Code	SA1 Mean	SA1 SD	SA2 Mean	SA2 SD	SA3 Mean	SA3 SD	Diff SA1, SA2	Diff SA2, SA3
TR218	62.75	6.40	61.85	5.96	59.95	6.98	0.90	1.90
JM218	64.67	5.26	59.39	7.70	60.89	8.16	5.28	-1.50
RT118	64.89	8.28	65.33	8.17	63.17	9.77	-0.43	2.15
TM118	65.73	8.67	67.07	9.58	63.87	9.01	-1.35	3.20
AS118	66.96	6.81	66.35	6.87	62.88	8.03	0.60	3.48
AT118	67.38	6.51	66.24	6.94	63.93	8.63	1.14	2.31
JM118	68.05	6.56	66.70	7.23	64.08	9.17	1.35	2.63
AT119	68.42	5.42	69.33	5.30	67.25	4.11	-0.92	2.08
LK118	68.50	5.76	65.86	7.36	64.16	7.21	2.64	1.70
TM218	69.86	6.92	67.76	8.26	67.86	8.64	2.10	-0.10

In three cases (RT118, TM118 and AT119) SA level 2 comprehension was higher than SA level 1 perception (see table 4 column Diff SA1, SA2). Truck – loader collision, fire (TM118, used 55 times) and gas explosion in building under construction (RT118, used 46 times) should not be used any more as they are overused (see Table 3 above). Inconsistency in those two scenarios may have been caused by the absence of key-person in first phase of incident. However, the bus and gasoline truck accident (AT119, used 12 times) should be continued to be used. To improve the scenario and get rid of the inconsistency that SA level comprehension is higher than perception, the only key-person alive – the truck driver – should have information available on paper. The documentation of gasoline truck should be added to the scenario as extra source of information. It would allow the IC to understand the situation in more details (number of sections, amount of gasoline, section leaking etc.) in convenient time for him/her.

Considering these findings, it should, however, be borne in mind that SA scores are also influenced by several other factors like the ICs and assessors' previous experiences, tiredness level, the IT tools used during the virtual simulation presentation like radio transmitters, screens, computers and so on. Still, we account the scenario storyline, dynamic and non-dynamic elements presentation using the XVR OS to be the most important factors for SA assessment.

DISCUSSION AND CONCLUSIONS

In this paper we analysed virtual scenarios that were used to assess the SA of rescue service ICs in Estonia. Our aim was to evaluate the process model for co-author virtual simulation scenarios for ICs authentic SA assessment in an organization. We found that the CAPM is feasible because of twelve scenarios co-authored and used. It helps to implement authentic virtual scenarios based SA assessment for assessments (SA level 1 mean 66.70; SA 2 mean 65.85 SA 3 is 63.68, see also Table 4). The virtual scenarios created with CAPM are used 341 times for formal assessments (see Table 2) and new scenarios ready to be used indicate successful implementation of CAPM in the organization. CAPM is a process model that allows systematic design, use of dynamic and non-dynamic situational elements while building the scenarios to assess ICs SA in practical setting.

For authentic Estonian IC SA assessment, virtual simulations need to be built to fit local needs (see Table 3). This finding fits with those from other studies using same virtual simulation software (Heldal & Wijkmark, 2017). The organization´s expectation was at least 10 scenarios in year. In average, only 5,5 were built in a year, resulting in the overuse of some scenarios (see Table 3). The need to design a larger number of scenarios to avoid "learning the scenario" to happen, is expressed also in the another study (Reis & Neves, 2019). Therefore, further research is needed to improve the effectiveness of using CAPM, as it allows to create scenarios that different trainers can use for ICs SA and DDM training to avoid overuse of the scenarios.

The pedagogical dimension, the feedback learner receives in the virtual environment (Duval et al., 2015), is presented visually using XVR OS, and audible input is given by an assessor, who plays the roles of key-persons defined in user manual. The virtual scenarios built using CAPM allowed ICs to collect information about the situation from audio and visual sources like fire plans, hazmat truck documentation, or talking with key-persons. The procedure dimension, to model the learners' activities in the virtual simulation, (Duval et al., 2015) the scenario maps are used in CAPM, as well as a user manual and the EASS virtual scenario building guideline to communicate the storyline of a scenario. The EASS virtual scenario building guideline helps to set the minimum standard while using situational elements in XVR OS for SA assessment. The use of the guideline helped to share scenarios between assessors and use the scenarios built by others. It gives guidelines, how to use the situational elements that can be divided into dynamic (victims, fire, leak, traffic) and non-dynamic elements (labelling, fire-plans etc.) in XVR OS.

We detected the situational elements for assessing ICs SA within scenarios in an authentic virtual training environment (RQ1). All scenarios included the dynamic situation change element of casualties to be rescued. Beside that fire, leak and issues from traffic were realistically visualized using XVR OS. An earlier study that collected feedback about scenarios´ difficulty from IC 53% self-reported the scenarios to be suitable for them and 33% noted that it was rather difficult (Polikarpus et al., 2020 p 212). We conclude that victims, fire, leak and traffic are dynamic situational elements to be used for storylines that include dilemmas to assess IC SA and DDM. Furthermore, we need more studies on how different elements in scenarios influence the SA levels of ICs.

We analysed how the consistency of the SA scores could be increased (RQ2). The analysis of SA scores showed that if the key-person is not easily accessible in the life saving phase of the incident, it makes it difficult for the IC to collect information, understand it, and predict the changes during the incident. Lower SA scores from scenario design could be improved by providing some information on paper to the commander, so they could return easily to the information on paper when they need it. Moreover, as the key-person is an important dynamic situational element, the fire plans or hazardous materials carrying truck documentation could be added to the scenario non-dynamic situational elements to serve as sources of information.

In the current study we examined the implementation of the CAPM and it turned out that SA level 1 perception scores were higher than SA level prediction scores. Similar results have been found in other studies. Our results, however, indicated that some storylines and virtual simulations can produce SA levels scores when in different order. The fact that different scenarios may produce different SA scores shows the need for further research of SA in general but also more specifically on how to create authentic virtual scenarios to improve IC SA training and assessment.

ICs show a positive attitude towards using virtual simulations (Wijkmark & Heldal, 2020). As training and assessment of DDM is challenging and engaging (Polikarpus et al., 2020) CAPM and simulations for ICs training should continue to be used and researched for practical purposes. To conclude, the CAPM enforced the building of assessment scenarios collaboratively inside the organization and that helped to share knowledge and experiences between assessors. Shared virtual scenarios building guidelines and process model helped to contribute to the authentic SA assessment.

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