Using Scenarios in a Living Lab for improving Emergency Preparedness

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Abstract

Emergency preparedness and management processes are highly influenced by the use of digital technologies. Unfortunately, due to their rapid development, stakeholders from civil protection as well as policy makers often are not aware of new technological possibilities, their potentials and risks. This paper offers a methodological approach to experience evolving technologies by using scenarios in a living lab, equipped with demonstrators from recent research projects. The scenarios are presented to stakeholders from civil protection and policy making by telling a future story about the potential usage of emerging technologies. The Future Security Lab allows addressees to see, understand and use technologies that may become relevant within the next five to ten years and so a profound basis for knowledge transfer is offered. The case study "Digitalization of Emergency Preparedness 2025" demonstrates how scenarios can be used to integrate demonstrators in stories about the future of civil protection. First results of an evaluation provide positive feedback from attendees.

Keywords

Civil Protection, Emergency Preparedness, Scenario, Living Lab, Knowledge Transfer.

Introduction

Emergency management nowadays is highly driven by technological developments in all relevant fields and phases of the emergency management process (Roth et al., 2014; Prior et al., 2016). Emergency management therefore faces a new period of digitalization that will largely influence how civil protection organizations cope with emergencies in future. Herewith the general trend of digitalization raises questions of how to safeguard the public in a complex and interdependent society in future. Many modern technologies have been developed to address these questions, but the field of emerging technologies is often non-transparent to those addressed by these technologies (Bierwisch et al., 2015).

This paper provides an overview of the methodological approach of using scenarios in living labs for improving emergency preparedness. After introducing the Future Security Lab (FSL) as a living lab, a short introduction to the basic understanding of knowledge transfer is given. Knowledge transfer in the FSL is operationalized by the use of scenarios, which leads to a description of how the scenario technique is used to develop a story about the future based on findings from recent research projects in the field of civil protection. The process of how scenarios for the Future Security Lab (FSL) are developed will be outlined in detail here. Within the FSL scenarios are developed concerning several topics from civil protection. The next section introduces a case study focusing on "Digitalization of Emergency Preparedness 2025" and gives examples of recent developments in security and civil protection research that might have a strong influence on the future of emergency management. The following section contains an initial approach to evaluating the FSL. The paper concludes with a discussion of preliminary results.

THE FUTURE SECURITY LAB (FSL) CONCEPTUAL APPROACH – A LIVING LAB

In emergency response and crisis management, it is essential to be aware of potential risks and threats and to be prepared in case of an emergency. New digital technologies promise support in emergency preparations and processes, although the outcomes of their use are often difficult to foresee (Bierwisch et al., 2015). Therefore, innovative concepts are needed to enable discussions on emerging social and technological innovations in emergency preparedness to improve the work of emergency response organizations. Foresight-oriented approaches try to give an idea of potential future situations and illustrate the possible consequences of contemporary developments (Gerhold et al., 2019; Federal Ministry of Defence UK, 2018). Further, it is necessary to create space for an open-minded and transdisciplinary discussion about future innovation.

A living lab is an example of one such innovative space. In the context of the Future Security Lab (FSL), a living lab is understood as an open space for feedback on technological innovations in security contexts. Because of their potentially high impact on society, it is necessary to discuss such innovations openly. The living lab FSL aims at creating a space to experience new technologies and enable a broad array of stakeholders to reflect on innovations from the field of security (see also Ballon and Schuurman, 2015; Schuurman and de Marez, 2012).

The FSL follows this path and addresses a) decision makers in the field of civil protection, b) emergency responders and c) policy makers in the field of public security:

a) Decision makers in the field of civil protection are those representatives of civil protection organizations that are responsible for the acquisition and integration of new technologies in the emergency response process.

b) Emergency responders are members of aid organizations or fire brigades, who are not necessarily involved in the acquisition, but the use of new technologies in practice.

c) Policy makers are members of the German parliament (Deutscher Bundestag) or the federal state parliaments (Landtage). They are addressed, because civil protection organizations in Germany depend highly on financial as well as technical support enabled by political actors.

Figure 1. Overview Future Security Lab

Figure 2. Touch Displays

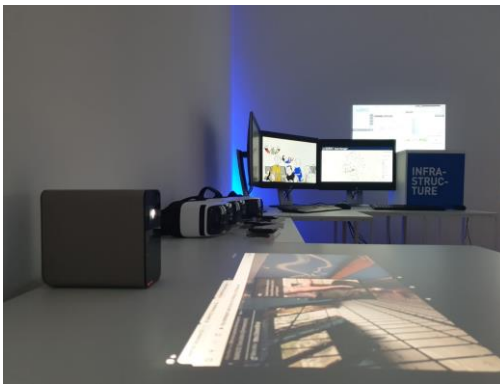

Figure 3. Different devices (touch table, VR goggles, displays)

Figure 4. Stakeholders from the Deutsche Bundestag and civil protection organizations discussing while scenario presentation

The FSL utilizes the openness of living labs to enable a discourse on future emergency technologies with these addressees. Supporters and critics of new technological solutions and propositions discuss potentials and threats of a number of new technologies not on a theoretical basis but based on the exhibits shown and used in the FSL

within scenarios that are presented to the attendees (Figures 1 to 4, see also "Knowledge Transfer within the living lab "Future Security Lab"").

Demonstrators were collected from recent research projects (mainly in Germany). As German security research funding is limited to Technology Readiness Level (TRL) five to six as a Technology Demonstration (COMMISSION REGULATION (EU) No 651/2014), results from R&D projects are in working progress and still open for feedback and improvement. The concept of the FSL makes use of this fact in two ways: first, decision makers and politicians discuss legal and political frameworks to implement (or prevent the use of) a technological product. Second, feedback is employed to enhance the concept and usability of the innovation in order to improve its chances for use in emergency management.

Living lab as a concept is not uniquely defined (Hossain et al., 2019). A concrete comparison between labs is challenging therefore. In the FSL, different stakeholder are confronted with new technologies and future challenges. Although organizational and individual reflections might be shared in discussions, not all envisioned end-users are always present. The advantages of the comprehensive approach to present technologies contextualized through a scenario, embedded into an assumed deployment and an open discussion between addressees outweighs the existing shortcomings.

KNOWLEDGE TRANSFER WITHIN THE LIVING LAB "FUTURE SECURITY LAB"

Knowledge transfer depends on several aspects, ranging from individual conditions to organizational or technical limitations. Definitions of knowledge vary widely (Mittelstraß, 2002; Jost and Richter, 2015; Reinhardt et al., 2011; Stehr, 2000) as they do for transfer (Gräsel et al., 2005; Schmid, 2006). But all definitions essentially describe a utilization of knowledge gained from context A in context B (Vigerske, 2017, p. 33).

Security research and emergency management are complex and highly dynamic fields. Technological, social, organizational and political aspects are intertwined when it comes to an assessment of current or future risks and the decision processes underlying how to cope with these risks. It is difficult to grasp the impact of emerging risks comprehensively, especially for non-experts like politicians. Nevertheless, those decision makers rely on credible sources to back up decisions. Therefore, labs like the FSL are needed to inform addressees about a project or research result and foster critical contemplation in terms of a "reflexive knowledge policy" (Wehling, 2004; Böschen, 2005). Böschen (2005) pleas for open procedures and involvement of different actors on problem solving. He calls it "reflexive" since it includes the state of not knowing. Becoming aware that not all consequences of innovations are foreseeable easily or are recognizable at all is an improvement when it comes to decisions in the sensitive field of crisis management and security.

Lavis' knowledge transfer framework (Lavis et al., 2003) is used as the underlying concept of transfer within the FSL, whereas the knowledge formation is an individual and subjective process (Geiger 2006, p. 311). Lavis asks five main questions that should be answered to enable knowledge transfer in general:

1. What should be transferred to decision makers (the Message)?

The message to be transferred in the FSL is: These are potential future challenges you may have to deal with in emergency management and these are some of the technological solutions that might help you. But they may come with costs and side effects.

2. To whom should research knowledge be transferred (Target Audience)?

a) Decision makers in the field of civil protection, b) Emergency responders and c) Policy makers in the field of public security.

3. By whom should research knowledge be transferred (Messenger)?

The messenger needs to be familiar with the details and context of the research projects presented in the FSL. He or she has to translate research findings into reasonable and easy to grasp stories, accessible even to attendees who are unfamiliar with every detail of the described situation. It is important to offer detailed information when necessary but to avoid overly technical or expert-level language. At the same time, the messenger should know not only the background of the addressee but also be able to offer the addressee paths to comprehension of that information and how that information can be used. The main staff at FSL have this ability. Besides a short presentation, attendees are invited to test and use the exhibits. In this way, questions about the technologies, their benefits and their potential negative effects arise. Therefore, the messenger does not convey the messaging alone but rather initiates the message in a way that enables visitors to learn from each other (see "Evaluation").

4. How should research knowledge be transferred (Knowledge transfer process and communication infrastructure)?

The exhibits are presented in a narrative scenario which is provided by the staff (see "Scenario Development") as a spoken story about a potential situation in the future. While telling the story, demonstrators and other tools are handed to the attendees. Within the lab we use computers with touchable and non-touchable displays, large-scale beamers, extra-large wall-mounted displays, various tablets, VR headsets, a VR system (HTC Vive Pro), firefighters' gear and several specific demonstrators. More than 45 results from research projects have been included and implemented in the FSL. The technical infrastructure of the FSL uses a self-developed control software to trigger separate materials on different kinds of devices. It is possible to show different scenarios instantly and without any physical adjustment to the technical infrastructure.

5. With what effect should research knowledge be transferred (Evaluation)?

The main goals of knowledge transfer are: information, communication, reflection and discussion. Research literature shows that knowledge is transferred more successfully, if a number of criteria of the innovation are met, like visible advantages of an innovation or an adaption to the expectation of recipients (Rogers & Shoemaker 1971, Gräsel et al 2006). Regarding the FSL it seems to be promising if attendees not only become active and interact with the exhibits but also when they discuss challenges, potential solutions or (non)-intended side effects of innovations Gräsel (2005). Within this approach, the concept of knowledge transfer not only includes a transfer of knowledge about new opportunities to the recipients but also entails co-creating knowledge (Renn 2019) by confronting stakeholders with possible future developments and their potential consequences, leading to new insights. At this point, Böschens concept of "reflexive knowledge policy" comes into play in terms of an innovative policy to include new knowledge and perspectives in political decision-making. In the FSL, knowledge transfer is less of a speaking-truth-to-power-approach but more of a reflecting-on-consequences-concept.

SCENARIO DEVELOPMENT IN THE LIVING LAB

As mentioned before, scenarios are used to support knowledge transfer with the FSL. Therefore, the FSL is equipped with tools and technologies that display results from those security related research projects funded by the national and international programs referred to previously. Based on a scenario approach, a story of potential futures is told. Narratives are supported by the presentation of the tools and technologies. With this approach single projects should be embedded into a bigger picture:

In which context is this project relevant? Why is this solution innovative? What is the current state of the art? The combination of different devices helps to reduce a complex situation to a couple of pictures, videos or sounds: a sound alarm in combination with footage on different screens showing panicking people in the streets conveys the challenges of a confusing situation much faster and more effectively than a five-minute speech.

It is necessary to develop and implement an advanced strategy for presentation. The FSL staff have developed narrative scenarios to describe not only the context of a single project but to weave a number of projects into a plausible narrative scenario. Narrative scenarios are useful in two ways: (1) a theory-based scenario morphs into an entertaining story but is backed by facts and figures, and (2) a scenario enables visitors to immerse themselves in a possible future situation or context and to experience this situation with and without the suggested technological or social innovation. This experience highlights the usefulness of a solution and triggers a complex process of reflection.

Scenarios are a well-established methodological approach in futures research and foresight (Glenn, 2003; Steinmüller, 2012). Nevertheless, scenarios can be developed in many different ways and there is a wide range of perspectives on what constitutes the nature of a scenario. In this paper, we understand scenarios as homogeneous and plausible depictions of the future. We therefore focus on possible future developments. That means that all described and displayed future developments in crisis prevention are based on technologies that have not yet been implemented but which could have the potential to be realized in future (Steinmüller et al., 2012). This does not include an estimation as to whether these developments are likely or in a normative sense even desirable. This theme in turn forms a key part in feedback and discussions with stakeholders from the fields of civil protection and policy making who visit the lab.

The development of a scenario follows these steps (Table 1):

Table 1. Methodological steps of the scenario process

Methodological Step	Example
Definition of Scenario Field	The theme of the scenario has to be defined, e.g.: "Digitalization of Emergency Preparedness 2025". Here the definition is: digitalization of administration, coordination and services as well as new digital services and solutions before, during and after an emergency. It includes emergency organizations as well as other groups affected by them and their activities: society, media, politicians, etc.
Background research: overview of the field, key research fields, identification of recent findings, desideratum	The most relevant stakeholders in crisis management are identified. Review of main aspects within the scenario: structure of the organizations, responsibilities, history of events and so on. Recent research on stakeholder behavior, such as increase in resilience of first responders or use of social media as a resource to gain an overview of an emergency situation. Open research questions like "how to verify information delivered by a social media user?"
Identification of current and recently completed research projects in the scenario field	In Germany, there exists databanks for publicly funded security research projects from the Federal Ministry of Education and Research (https://www.sifo.de) and the Federal Office of Civil Protection and Disaster Assistance (BBK) (https://www.bbk.bund.de). Besides these resources, additional search engines are used to gather research projects linked to the scenario.
List of included key features	All research projects are sorted by means of a number of categories including main topic, results, and end of project.
Development of a Storybook, including technological implementation	The material from the research projects is arranged regarding (1) a relation in topic, and (2) the best way to present (e.g. big screen, touch screen, exhibit). This way, a number of thematic foci and a rough chronology appear.
Scenario writing	The team develops a narrative scenario which has a plausible story, includes relevant contextual information and enables a deeper understanding of the relevance of the research results in an accessible way, based on material from research projects, background research and desiderata.

CASE STUDY: DIGITALIZATION OF EMERGENCY PREPAREDNESS 2025

As an example, the theme "Digitalization of Emergency Preparedness 2025" will be presented here: This broad topic was cut down to three main categories: development of situation reports, emergency response, and prevention. The developed scenario consists of

a) a number of current research projects on these topics (Table 2), which were selected regarding four criteria: a) a high relevance for the topic, b) passing at least half of the project time (results are produced already) and not finished to longer than one year ago, c) the project sent some material in, and d) the projects fits with the final scenario (in terms of the storyline).

b) desktop research regarding current and potential future challenges with digitalization.

c) a plausible scenario (see next section) in which the findings would make a difference to the current situation in an emergency.

Table 2. Relevant research projects and categories used

Research Project	Keywords	Category
EffFeu: Efficient Operation of Unmanned Aerial Vehicle for Industrial Firefighters	Firefighting, drones, plant fire brigade	Situation reports
SenSE4Metro: Sensor based security and emergency management system for underground metro systems during disaster events	Subway, sensors for detection of critical situations like heat, smoke, water	Situation reports
SAFEST: Social-Area Framework for Early Security Triggers at Airports	Surveillance technology, anonymization, dynamic emergency exit concept	Situation reports, Prevention
ENSURE: Enablement of Urban Citizen Support for Crisis Response	Incorporation of volunteers, support of first responders	Emergency response
KUBAS: Coordination of voluntary helpers to overcome disaster situations	Incorporation of volunteers, support of first responders	Emergency response
AUDIME: Audiovisual medical information technology for complex operational situations	Audio-visual support in complex situations, mass casualty incident	Emergency response
EFAS: Mission support system for fire brigades to combat danger on board seagoing vessels	Firefighting, fire on ships, information exchange between control center and first responders, smart wearable garments	Emergency response
SEERAD: Sea rescue system based on a low-interference radar	Sea rescue, radar-controlled tracking system	Emergency response
TEAMWORK: Crisis simulation for the cooperation of emergency forces and the population	Serious games, simulation of cooperation between emergency organizations and residents	Prevention

Scenario Description

The following story in the scenario has a plot, which is presented by a follow-up of different material, displayed by various devices and exhibits. It is intended for participants to move freely about in the room to keep attention levels up and form impressions by themselves. For a detailed description of the scenario "Digitalization of Emergency Preparedness 2025", see Table 3.

> *"We are in the port of Hamburg in 2025. About 150 million tons and countless passengers arrive at or leave the port per year. It is a working day in winter. The weather is rather stormy but no rain. The sky is cloudy.*
>
> *We are in the control center on a usual workday when the alarm goes off: a fire on a ship between the commercial and the passenger terminal. The clock is ticking. What do you do first? Right, gaining an overview of the situation.*
>
> *What is going on there? In the large area of the port it is not easy to get an overview, companies are in that area, a nearby subway and motorway might be affected very soon by smoke or fire. The emergency number registers a high increase in calls with contradictory information. A cargo vessel burns briskly. Others report fire on a passenger ship beside the vessel as well. Smoke covers the area. In sum: the situation is unclear."*

Table 3. Detailed scenario description in FSL

Story	Devices used	Short description of innovation	Innovation to display
First, you would send firefighters to the spot, right? However, it is not clear what is burning there: chemicals, cargo?			
At the same time, you are getting a call from the nearby oil company. Their security system recognized the fire and automatically initiated an aerial reconnaissance by a drone.	Two screens: one for the view from the drone, one for a detailed description of how the drone operates. Project: EffFeu	The system is created for plants and companies and includes an automated aerial reconnaissance by a drone, automated image recognition (how many people, cars, buildings, etc).	Drone, equipped with camera and sensors.
The caller reports fire and smoke across a wide area. The nearby metro might be affected. Nowadays, we do not get any information from inside the tunnels, but it would be possible through a sensor-based data net in 2025. Fortunately, there is no fire or smoke detected in the metro.	Two screens: one displays the image from a camera which shows only smoke – the current state of the art – the other shows a simulation of a dashboard which shows information on temperature, smoke, water in the tunnels around the affected area. Project: SenSE4Metro	The sensor system can work as an alarm system: if a limit is exceeded, the alarm is set off automatically in the next control center. If the control center needs to get information about a certain area, it is possible to extract the data from the sensors.	Video animation about the functionality of the sensor network. Real camera image of smoke in a metro station.
What about the terminal for the passenger ship? Especially in huge buildings people might panic if visibility is limited. The current emergency exits are indicated by static, glowing signs which still show the way to the next exit, even though the exit is unsuitable. In 2025 the surveillance system at the terminal will allow for the detection of crowds and will work as a dynamic system to display the best emergency exits.	A sensor on the ceiling of the room and a computer screen to show the crowd detection and the alarm. Digital display as an advertisement screen on which – in an emergency – dynamic emergency exits can be displayed. Project: SAFEST	The surveillance system works along with anonymization software and counts people by a combination of heat detection (from bodies), height measurement and motion detection. Only dots are displayed as a proxy for a person. The emergency system changes the path to the next usable emergency exit if it detects a crowd accumulation or a defective emergency exit.	The complete surveillance system including a display that shows the person and their movement in a defined part of the FSL: visitors can test the system and see the anonymized data presentation.
The firefighters arrive at the spot. Nowadays, this type of mission is still very dangerous. The heat could be enormous on a metal boat and firefighters risk their lives and health in a mission due to temperature, chemicals or gas. That is why in 2025 the new smart firefighter's overalls are deployed.	Smart firefighter's overalls Project: EFAS	Sensors included in the overalls are able to detect gas, chemicals and temperature inside and outside the overalls. Data are sent to the control center automatically.	Test the actual firefighter's overalls of the sensors by applying heat to them. Display on a tablet shows the increase in temperature measured.

Based on information from emergency calls and first responders you learn that a lot of people have to be cared for – too many people for the first responder. That is why you alert the volunteers.	Smartphones and handhelds are used to show the app and the alarm which would be displayed on devices of volunteers who have been registered – due to their background and experience – before the situation. The volunteers are able to support professionals. Projects: ENSURE & KUBAS	History has shown that increasing numbers of volunteers are willing to provide support in a particular situation but are not included formally in a specific emergency organization any more. Both projects have developed a system for registration, alerting and warning as well as coordination and communication via an app on a wearable device.	Applications for mobile phones that enable volunteers to be alerted. Relevant information was given to volunteers: Where? When? What to expect? Equipment? Duration? With a click, the volunteer can decide whether to support first responders in the emergency situation or not.
You get the information in your control center that a great number of passengers from the terminal require medical care – too much work for only a few ambulances and doctors. In 2025 audio-visual support would help to increase capacities through data glasses.	Data glasses are used to show how the identification of information works by a prepared example. A screen shows the incoming data and the functionality of the software. By this means, the entire system is depicted. Project: AUDIME	It is a time-consuming procedure to identify injured people, carry out a paper-based triage and bring all this information to the control center. By means of an audio-visual support system accessed via data glasses, an ambulance crew can perform triage on the spot with the support of a doctor and with all information digitally at hand.	Data glasses and screen including the software for automated image recognition.
You are suddenly informed that someone has jumped from the passenger boat in panic. They seemed to believe that there is a fire on board. You need to find them immediately. The water is only a few degrees Celsius. The control center instructs the passenger ship to activate its sea rescue measures: the double-radar localizing the newly designed life jackets.	A life jacket and a prototype of the sensor.	Especially in storms with high waves, it is very difficult to locate missing people. The innovation consists of two new features: first, the radar is able to find the sensors in the life jacket even in stormy waters. Second, the sensor is activated by contact with water only – no batteries are necessary to enable the system.	The life jacket and the sensor as exhibits are combined with a tablet showing the operating principles of the rescue system.
After the direct response to the event, you relax in the control center. There have as yet been no fatalities and most of the injured people are in a relatively good condition. The mission ends a few hours later. The fire is extinguished and the emergency teams are back in their stations. You assemble representatives from all organizations for a de-briefing. The findings are	A game station with a collection of missions from the TEAMWORK database.	Simulations of complex missions are quite difficult to design and undertake. Exercises and training programs are costly as well as time- and resource-consuming. The serious game from the project enables participants to "perform" in a number of complex missions in order to achieve a deeper understanding of logistics, interaction and strategy. It	The game console in the FSL can be used in single-player or two-player mode. In two-player mode, different ranks or organizations can be represented to help players to under-stand the dynamics of organizations or between organiza-tions of emergency

used to improve similar future missions by being fed into a powerful game-scenario that shows the importance of teamwork.	is even possible to develop own missions.	management.
Congratulations! You not only have dealt successfully with a complex fire situation but also used your lessons learned to improve measures and strategies for the next mission.		

EVALUATION

The use of the FSL is accompanied by an evaluation of its users so far. The FSL is still at a test-run stage so only scant evaluation data exist yet (N=73). Between the 25th of January 2019 and the 7th of January 2020, policy makers and practitioners from emergency management as well as students from multiple disciplines (computer science, futures research, security studies and logistics) and colleagues from various scientific disciplines who visited the lab, were invited to take apart in an online survey. Actually, students and scientists are not addressees in the proper sense of the FSL, but were asked to test the scenario described here. In addition, due to the lack of time, politicians from the German Bundestag usually do not take part in the evaluation process. This is why the results should only be seen as preliminary.

The evaluation provides feedback on different aspects of the scenario presentation. On the one hand this feedback indicates that the prescribed purposes have been reached. On the other hand, the FSL is a place for co-creation and knowledge transfer, so the evaluation represents an opportunity to improve certain critically viewed aspects and to integrate recommendations. To gather this information six items were selected as the subject of questions. The results are shown in Figure 5.

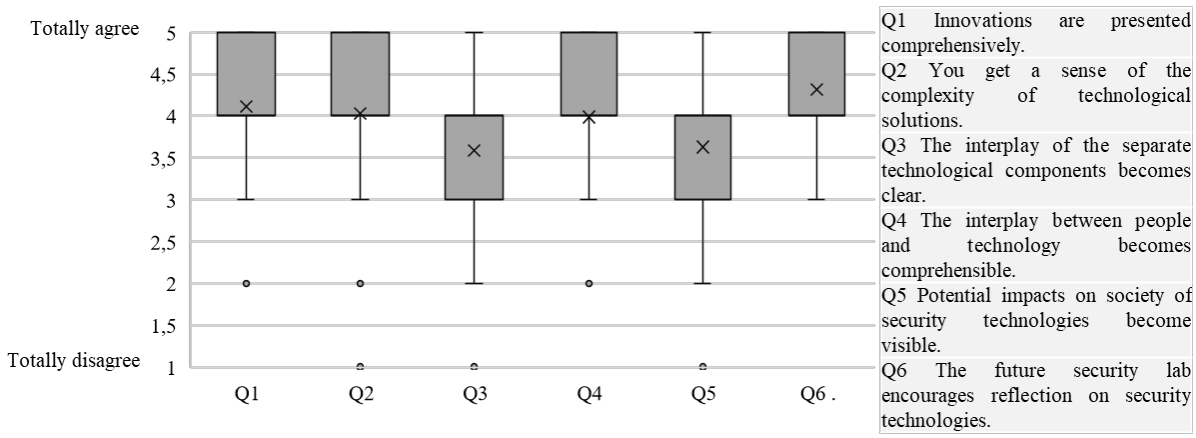

Figure 5. First Evaluation Results Future Security Lab (Boxplots, N=73)

The sample size (N=73) consists of emergency responders (17), politicans (3), experts of science and economics (23), students (17) and others (13).

The attendees were asked whether the technologies they were shown had been presented in an understandable way. Statistics indicate a high degree of comprehensibility for the displayed objects (Q1, M=4.12, SD=0.81). With regard to the demonstration aspect the results indicate that the potential for using the technologies was evident. The attendees gained an understanding of how to work with these technologies in civil protection organizations (M=3.99, SD=0.78). A deeper grasp of the interplay between technological components is less clear, though the values are within a promising range (M=3.61, SD=0.957). The scenario presentation concentrated on showing potential usage and implementation of technologies rather than providing lessons in operating principles and technical knowledge, and the results reflect this. Although a scenario is a method whereby complexity is necessarily somewhat reduced, the attendees reported that they had got a sense of the complexity of the technologies (Q2, M=4.01 SD=0.85). This indicates that reducing the focus on imparting technical knowledge in

favor of understanding, time saving and giving an overview does not represent a disadvantage for presenting links, connections and interdependencies between technological components, technologies and stakeholders. After the scenario presentation all attendees felt encouraged to reflect on the new technologies (Q6, M=4.31, SD=0.74). While all of them attested to this process of reflection, the visibility of possible impacts was rated as not so high (Q5, M=3.67, SD=0.96). A few respondents (9 of 76) stated that they had received no positive impacts from the presentation. This is clearly a result which could be improved upon in the future.

As a whole, all the aspects queried were rated good and indicate a high degree of unanimity among attendees. The comprehensibility and the demonstration of security technologies were valued highly, as they allowed most attendees to get a first-hand illustration of how these technologies work and could be used in future. The encouragement to reflect also highlights a well implemented aspect of the demonstration. The lab, in addition to offering possibilities to imagine potential use and fields of application, also provided a space for attendees to reflect critically on what they had learned. Nevertheless, this data is only from test runs and could not be differentiated between different user groups in a statistical way at this stage. Furthermore, there are only few data from the addresses in the proper sense of the lab as introduced in the beginning of this paper. It remains one part of the further examination of the FSL to draw attention on these groups.

Discussion

The technologization of civil protection has been a global trend especially since 9/11 (Ceyhan, 2008; Kaufmann, 2016). This raises questions as to how and to what extent the integration of digital security technologies in emergency preparedness and management organizations should be shaped. In this contribution an approach has been introduced to communicate the results of several research projects to decision makers and stakeholders in a demonstrative, comprehensible and reflexive way, which means not only to understand innovative technologies but to know how to use or avoid them. To place this concept of a living lab in a broader context and illustrate the self-conception and objectives of the FSL, the multi-level perspective is an appropriate framework (Geels and Schot, 2007). This perspective theorizes socio-technical change in a certain area, in this case its contribution to the field of civil protection in Germany, driven by emerging innovations regarding different levels. Bottom-up and top-down approaches are both conceivable within the model. On the micro level innovations are developed, improved and co-created in niches forming fragile arrangements or networks. At the next level up, the socio-technical regime, is the arrangement of existing technologies and procedures on a meso level, occupied by a broad network of stakeholders who form trajectories and transitions of existing and future technologies, affecting their implementation and use. The macro level, the socio-technical landscape, provides an exogenous environment with long-term and relatively fixed conditions (e.g. laws and value systems). For possible changes in intellectual regimes, patterns of thinking or, even further, a socio-technical change, innovations need to first emerge from a niche level, replacing the existing mode of operation or joining new modes together (Geels and Schot, 2007).

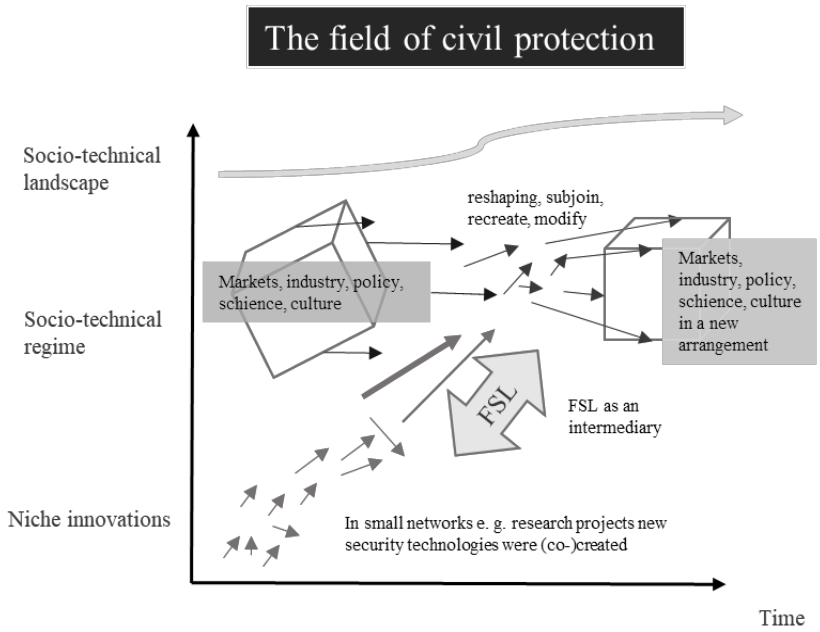

Figure 6. The Multi-Level Perspective (Geels and Schot, 2007, supplemented by authors)

Within the framework of the multi-level perspective, the FSL positions itself as an intermediary between the niche and the regime level, supporting stakeholders on the regime level to make decisions and form trajectories with regard to innovative technologies, see Figure 6. The aim of this approach is to transfer knowledge from civil protection research to stakeholders from emergency response organizations and from the policy making realm. From the authors' perspective this mediating role could be viewed as what Renn terms catalytic science (Renn 1999; Renn, 2019). By using scenarios in a living lab, knowledge about emergency response research is systematically collected, converted and made comprehensible. The presented scenarios and the discussions with attendees lead to processes of reflection about potential future developments in crisis prevention. It makes stakeholders think and reflect about the advantages and the potential unintended side effects of implementing and supporting emerging security technologies within their respective organizations.

ACKNOWLEDGMENTS

We thank the Federal Ministry of Education and Research for the funding of the Berlin Future Security Lab (Funding Number 13N14842). We would also like to thank all researchers and research institutions that provided demonstrators to our lab and supported our work by making available to us their research findings.

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