# First Evaluation of the Usability and Usefulness of the PROACTIVE App

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**ABSTRACT**

One way to reduce the communication challenges associated with Chemical, Biological, Radiological, Nuclear and explosive (CBRNe) incidents management could be a public facing disaster smartphone app, of which none are currently available. The EU funded project PROACTIVE used an iterative, co-creation methodology to develop such an app. This work-in-progress paper examines the preliminary results of a questionnaire given to observers who were tasked with using the beta app during a first field training exercise. The results show that the app was found to be usable and useful. Based on the results of the current evaluation exercise, the app will be updated, taking into account the end-user inputs. Following which, the app will undergo testing in two additional field training exercises, in an iterative manner, before reaching the final, end-of-project version.

**Keywords**

CBRNe, Universal Design, disaster apps, co-creation, user interface.

## INTRODUCTION

Chemical, Biological, Radiological, Nuclear and explosive (CBRNe) incidents present unique challenges for disaster management and crisis communication. For example, first responders may need to wear Personal Protective Equipment (PPE), which includes face masks, when interacting with victims and victims will most likely undergo unique protocols such as decontamination. Furthermore, while all disasters can lead to anxiety, seeing practitioners arrive in PPE on the scene while waiting to begin decontamination has been found to induce fear (Carbon et al., 2021).

These challenges are only compounded by the fact that public awareness of CBRNe incidents is low, which means that the public at large is likely to depend even more than in other types of disasters on the communication and technology employed by practitioners (Hall et al., 2020). One way to overcome or at least reduce these communication challenges as well as the public's anxiety about such events could be a dedicated CBRNe disaster app. Disaster apps are a widely recognized, useful tool for disaster management, contributing to the reduction of anxiety (Bossu et al., 2018), yet few available apps address the CBRNe topic (Petersen et al., 2021).

That said, it is important to keep in mind that the public is not a homogenous mass and a switch must be made from interacting with the public on a 'one-size-fits-all' basis towards more nuanced planning and preparing to deal with the range of individuals that together constitute a diverse 'public', e.g., disabled persons, older persons (Petersen et al., 2019). Unfortunately, rarely are digital tools for emergency management, including public facing disaster apps, designed with accessibility in mind (Gjøsæter et al., 2021).

Accessibility is a key component of social sustainability and inclusiveness, contributing to usability and durability – as stated in the European Accessibility Act (European Commission, 2019). It may be argued that accessibility

should have a key place in disaster apps, as when a disaster occurs, anxiety is likely to be high and therefore comprehension levels reduced. This is an effect known as situational disability, as indeed circumstances surrounding a disaster may lead to temporary impairments (Gjøsæter et al., 2019). One way to help make disaster apps accessible is to include universal design principles from the beginning of ICT (Information and Communication Technology) tool development (Radianti et al., 2017). Universal design is defined as the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities. It is based on the following seven principles as elaborated by Connell et al. (1997): equitable use; flexibility in use; simple and intuitive use; perceptible information; tolerance for error; low physical effort; and size and space for approach and use.

The EU H2020 project PROACTIVE (PReparedness against CBRNE threats through cOmmon Approaches between security praCTItioners and the VulnerablE civil society) presents a novel solution in the form of a mobile app to i) provide a public-facing CBRNe disaster app while ii) minimising the accessibility gap in such kinds of apps.

## THE PROACTIVE MOBILE APP

The PROACTIVE mobile app was developed following the above-mentioned principles of universal design, based on input from the project's desk research phase, the experience of the app developers and a co-creation methodology, whereby both CBRNe practitioners and the civil society beta-tested a web-version of the app, as described in Petersen et al. (2021, 2022, 2023).

The app aims to improve the efficiency of communication between Law Enforcement Agencies (LEAs) and citizens around CBRNe incident preparedness and response by allowing LEAs to inform the public about ongoing incidents, to allow the public who have registered as app users to report to LEAs, and by providing CBRNe preparedness information materials to anyone who has the app.

Therefore, the app administrator is intended to be the LEA who would be responsible for CBRNe incident response and the main user of the app is intended to be the public at large. The app administrator/LEA would send the in-app notifications, create the incidents viewable on the app, receive the reported incidents from the registered public users and choose which information materials to include in the app repository.

The beta version of the mobile app (Figure 1) has the following four main features:

(i) In-app notifications: allow the administrator to push information about an ongoing incident. They are accessed by clicking on the "news" button at the bottom of the screen (Figure 1B).

(ii) Incident List: this section of the app shows the geographical location of all the incidents added to the app by the app administrator. The app administrator may include the following information about an incident: time, date, location (via GPS or manually inserted), classification (emergency, non-emergency), status (ongoing, awaiting information, resolved), headline, description and choose whether or not to send out an in-app notification.

The incident list is accessed by clicking on the "map" button at the button of the screen and a given incident can be seen in Figure 1D. Incidents are presented on a scrollable map and, below, a short description can be seen. More information can be found for each incident by clicking on either the dot on the map or the incident on the list.

(iii) Report an Incident: allows registered public users to provide information (e.g., time, location (via GPS or manually inserted), photos, description) about a suspected CBRNe incident. This feature is intended to aid CBRNe practitioners in evidence and information gathering (Gavel et al. 2021). It is accessed by clicking on the red button seen on the home screen (Figure 1A), and the screen to actually report the incident can be seen in Figure 1C.

(iv) CBRNe Information: is a repository of public pre-incident information materials which are downloadable as PDFs. It can be accessed by clicking on the blue button on the home screen (Figure 1A) and looks like Figure1E.

## METHOD

This paper examines the preliminary results of a questionnaire on the usability and usefulness of the beta version of the PROACTIVE mobile app which was first tested during a field training exercise by observers.

### Observers

The ISO 22398:2013 Societal security — Guidelines for exercises (ISO, 2013) defines an observer as an "exercise

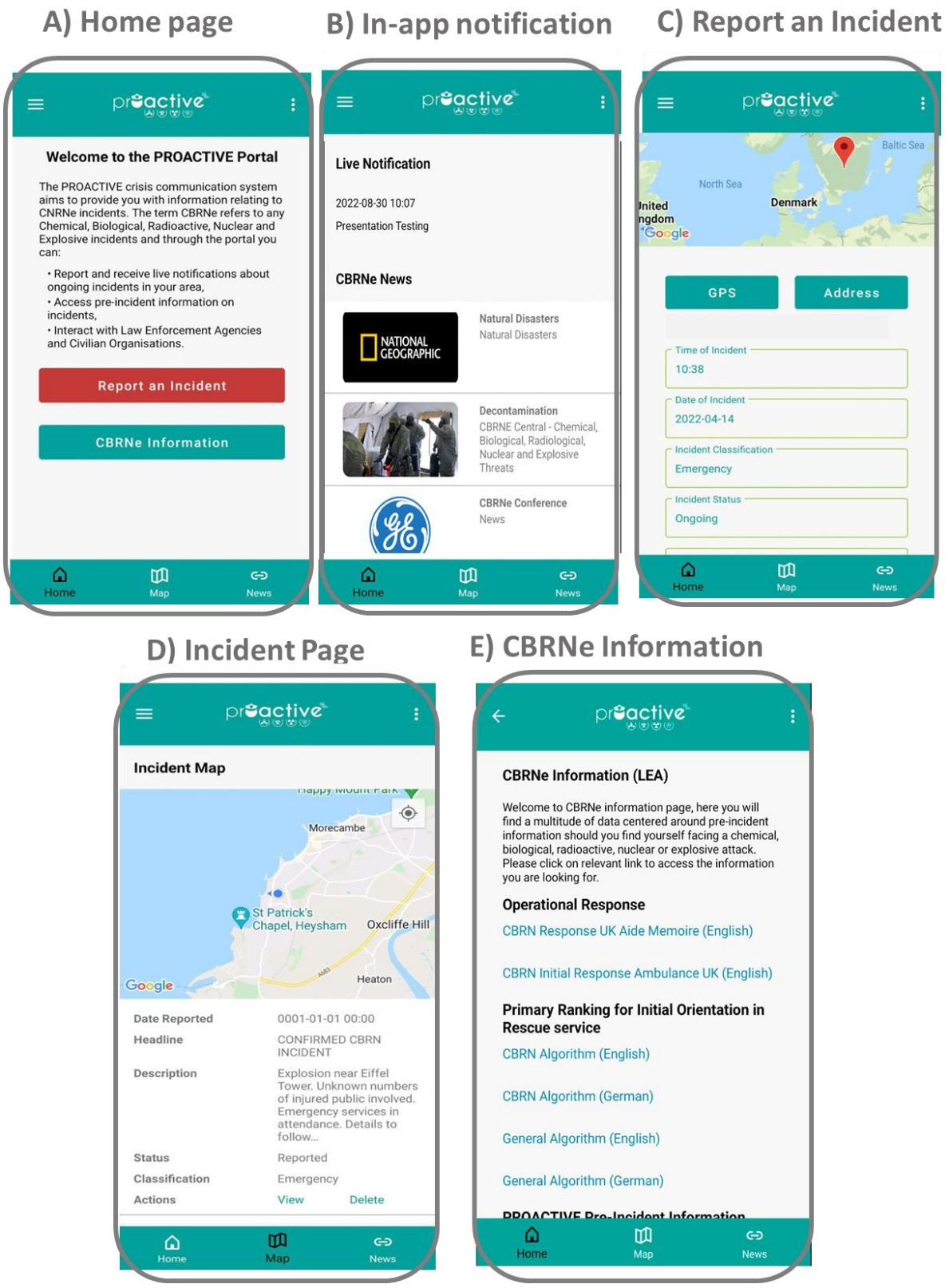


**Figure 1. Graphic user interface (GUI) overview of the PROACTIVE app**

participant who witnesses the exercise while remaining separate from exercise activities." Traditionally, the people invited to act as observers of a given field training exercise are security practitioners (e.g., firefighters, law enforcement, civil protection) with good knowledge of expected response protocols and standard operating procedures. A unique aspect of the PROACTIVE project was to also invite representatives of civil society organisations to attend the exercise as observers, to better understand the needs and expectations of the public during such incidents. As such, observers for the PROACTIVE field training exercise were drawn from the two advisory boards of the PROACTIVE project: the Practitioner Stakeholder Advisory Board, made up of CBRNe practitioners, and the Civil Society Advisory Board, made up of civil society organisations.

During the field exercise one of the roles assigned to observers was to role play a witness to the incident who would use the PROACTIVE app as a registered, public user to a) look for information about the ongoing incident and b) use the 'report an incident' feature. In total, 33 observers were present for the field training exercise, of which 19 filled-in the questionnaire.

### Field Training Exercise Scenario

The field training exercise took place on 7 May 2022 in Dortmund, Germany and was hosted by the Fire Department in Dortmund (FDDO) at their Civil Training Centre. The exercise was based on a scenario of a chemical substance from a freight train being released near a train station, leading to a specialised operational response. The chemical leak was simulated using disco fog in order to increase realism. The exercise was run in German and focused on the decontamination phase of emergency response. FDDO involved 130 firefighters who trained their decontamination skills. The role of victim was played by members of the local community, as opposed to the usual practice of off-duty first responders. The volunteers underwent disrobing, showering and rerobing.

During the field training exercise, seven pre-defined in-app notifications were sent out by the PROACTIVE app administrator, simulating notifications that would be sent by a LEA in the case of a real incident (Table 1). Each notification was sent in both English and German. Furthermore, the app was translated into German and available in both languages during the exercise.

| Time | Notification |
|---|---|
| Exercise start | It is confirmed that an incident occurred around 07.00 this morning on the 7th May at the local railway station. Reports have been received of smoke near a train. Please avoid the area as much as possible. Further information is being collected, please check this App for further updates. |
| +45 minutes | Confirmation received of a chemical substance leak requiring full decontamination. All people involved in the incident are being asked to remain calm, stay in the designated area indicated by the Fire Brigade and wait for instructions. |
| +1 hour | People requiring First Aid are asked to make the authorities on site aware of their needs |
| +1 hour 15 minutes | First responders have arrived on scene. A decontamination procedure is underway. Please keep calm and follow the instructions provided by the Fire Brigade on site. |
| +1 hour 30 minutes | The situation is now under control, the people affected are in the process of decontamination and no further risk to the public is perceived at this point. We continue to ask the public to stay away from the area until further notice. |
| +2 hours 45 minutes | People effected have been decontaminated and are being supported by the team on site. If you are looking for a loved one please contact your local authority through existing channels. |
| End exercise | The exercise is now over! |

**Table 1 In-app notifications**

### Questionnaire

As part of a larger questionnaire of 43 questions entitled the Observer Guide (Carbon et al., 2022), this paper focuses on the questions related to the PROACTIVE mobile app only. The entire Observer Guide was given ethics approval by the PROACTIVE Project Ethics Officer under approval reference: no15/ 26.04.22. Observers were asked to sign an informed consent sheet which explained that their participation in the research was completely voluntary, could be stopped at any time, and that filling in the questionnaire was not mandatory. The questionnaire was distributed in paper format.

The questions on usability and usefulness of the app were developed based on relevant disaster app literature (e.g., Tan et al., 2020) and the available features of the existing app. The questionnaire was composed of 16 questions, with answers on a Likert-type scale ranging from strongly disagree (1) to strongly agree (6) for questions 1 to 12, from not at all useful (1) to very useful (6) for question 13 to 16 on the app features. Respondents also were asked to explain their answer in an open-answer format for all questions.

The first questions focused on aspects of usability:

1. I felt confident using the app
2. The app design is easy-to-use
3. Most people would learn to use the PROACTIVE app quickly
4. The app has effective accessibility features
5. The amount of text displayed was appropriate
6. The visualisations were appropriate
7. It was easy to find critical information about the incident (e.g., time, location, severity)
8. I was able to find information resources/ materials on the topic of CBRNe

The next set of questions focused on usefulness:

9. I would use the PROACTIVE app in the case of a real CBRNe incident
10. I was confident that the incident information I saw on the app was the most recent update
11. The PROACTIVE app enhances the situation awareness of the population on CBRNe events
12. The app respects my privacy (e.g., the privacy statement, GDPR obligations)
13. In-app notifications
14. Incident list
15. Maps showing incidents
16. CBRNe Information Library

The questionnaire responses have undergone a preliminary analysis, both quantitatively and qualitatively. For the Likert scale answers, the average rating is reported, and a higher average score represents a better performance. The content of the open answers provided by the observers were analysed and reported in a qualitative way. The focus was to understand why certain observers provided a lower rating and what were their suggestions for improvement.

### Sample Description

The majority of respondents represent CBRNe practitioners (61%) (Figure 2). The majority of the respondents (71%) were also unfamiliar with the PROACTIVE app before the exercise (Figure 3).

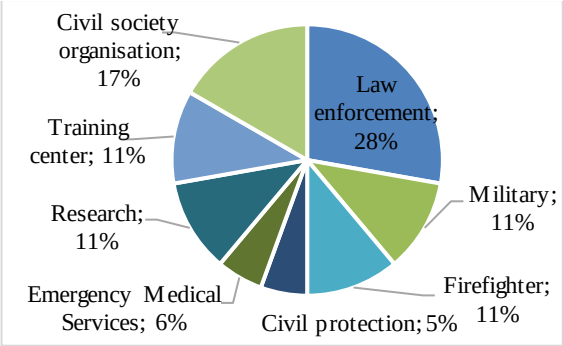


**Figure 2. Category of the respondents**

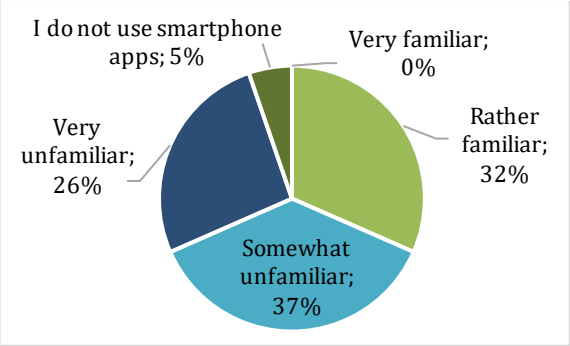


**Figure 3. Familiarity with the PROACTIVE app before the field training exercise**

## RESULTS

Overall, the PROACTIVE app averaged the score of 4.0 on usability (see Table 2 for detailed answers) and 3.9 (see Table 3 for detailed answers) on usefulness.

| Question | Number of responses | Average Score | Qualitative Feedback |
|---|---|---|---|
| 1 | 16 | 3.2 | Registration issues, no time to understand the app |
| 2 | 14 | 3.9 | Simple to use, some technical issues (crashes) |
| 3 | 14 | 4.2 | Simple to use, concern for the elderly, technical issues (crashes) |
| 4 | 11 | 4.0 | Suggestions to include language flags and more symbols |
| 5 | 12 | 4.3 | Well balanced, some translation issues |
| 6 | 11 | 4.2 | Use of pdf files not appropriate, map to include additional layers |
| 7 | 13 | 3.4 | Language options to be clearer, use images for incident updates |
| 8 | 12 | 4.5 | Easy to find, clear and useful information. Use of pdfs advised. |

**Table 2 PROACTIVE app usability**

| Question | Number of responses | Average Score | Qualitative Feedback |
|---|---|---|---|
| 9 | 14 | 3.0 | Yes, if linked to national processes and available in local languages |
| 10 | 13 | 3.3 | Technical Issues prevented this feature being tested |
| 11 | 13 | 3.9 | Suggestion to be part of existing national processes and apps. |
| 12 | 12 | 4.6 | Suggestion to include privacy audit and compliance with standards |
| 13 | 12 | 3.9 | Notifications are useful to verify incidents, but must work flawlessly |
| 14 | 11 | 3.7 | Useful for multiple stakeholders, suggestion to focus on only live incident and possibility to categorise and/or filter incidents |
| 15 | 12 | 4.5 | Maps negate language barriers |
| 16 | 12 | 4.3 | Good feature, only for use outside incident |

**Table 3 PROACTIVE app usefulness**

## DISCUSSION

### Technical Issues on the Day Appear to Have Impacted Both Usability and Usefulness Scores

On the day of the field training exercise, the PROACTIVE app experienced some (serious) technical difficulties, i.e. the app crashed or froze, clicking on notifications led to an error message, the scroll option was disabled for some users, users who had not yet registered or had forgotten their passwords found it difficult to access the app. However, with support from the on-site technical team, 90% managed to successfully gain access. While not an unusual occurrence for the first time an app or other new technology is tested in a real-life setting, this understandably would influence the questionnaire responses received.

Indeed, the qualitative analysis demonstrates that this is what influenced many of the lower scores, with open-ended answers of "it did not work" or "it kept crashing/freezing" given throughout the questions on usability. Other respondents were able to look past the technical difficulties, for example one observer gave a score of 5 and left an open-ended response of "if it worked" to Q3. These respondents tended to provide rather positive qualitative feedback, such as "the app is self-explanatory," "it is intuitive" or "it is easy to find things." Hence, with an average usability score of 4, it would seem that the observers felt that the PROACTIVE app was usable despite the technical issues, or would be usable if it had worked properly.

These technical issues seem to also have impacted the reported usefulness of the PROACTIVE app. Indeed, if the notifications were not working, and the app kept crashing, it is understandable that observers might not have been sure if the information they saw was from the most recent update (Q10) and were critical of the in-app notification feature (Q13), commenting that it would need to "work flawlessly" to be useful. That said, the average usefulness score of 3.9 seems to indicate that observers felt the app would be, once again, useful despite the technical issues experienced during the field training exercise.

### PROACTIVE App Features Could Be Improved

The features were overall deemed useful by participants and it also averaged highly on privacy concerns. With an average of 4.2 for effective accessibility features, it is clear that improvements should be made. Furthermore, qualitative feedback on other questions, not directly related to accessibility, also pinpointed ways forward to ensure the app is developed in line with the principles of universal design, such as using symbols and images to replace the heavy reliance on the written word, avoiding language barriers and making it available in multiple languages. The suggestion to use a country flag to depict which language the app is currently being shown in will be taken forward in the app redesign process.

### Usefulness of Yet Another Disaster App Questioned

With a score of 3, it can be said that respondents do not believe they would use the app in the case of a real CBRNe incident. The main qualitative feedback to explain this score was linked to the fact that the app is, as one observer put it, "not connected to national system," and others weren't sure of its added value when compared to other, already existing disaster apps or social media platforms.

This is in line with previous research findings on crisis communication, social media and disaster apps. During a crisis, people tend to turn to the communication channels they use in their everyday life to find information about the crisis (e.g. Steelman et al., 2014), and since disasters are hopefully rare, it can be assumed that few people will have downloaded such an app prior to the given crisis (Petersen et al., 2018). Indeed, a recent representative study of German citizens found that only 16% have downloaded a disaster app (Kaufhold et al., 2020). Furthermore, many studies demonstrate that users prefer to have a single app which would cover all hazards and threats, rather than a single app for each different one (e.g., one app for earthquakes, one app for terrorist attacks) (e.g., Dallo & Marti, 2021; Kaufhold et al, 2020; Haunschild et al. 2022).

As far as being integrated into a national system, the PROACTIVE app is intended to be administered by the local LEA and is being designed so as to easily integrate with legacy systems, thus hopefully meeting this end-user requirement.

## FURTHER WORK

In terms of research, it is foreseen to delve deeper into the data presented in this work-in-progress paper, for instance by comparing the responses from CBRNe practitioners to those of civil society organisations.

Furthermore, as part of the iterative, co-creation cycle, the avenues for improvement identified by the questionnaire respondents are planned to be implemented in a new version of the PROACTIVE app. This newer version of the app will then be tested in the second PROACTIVE field training exercise, whereby once again feedback will be collected from observers. The third and final PROACTIVE field training exercise will be run using the same methodology. After the last round of improvements, the PROACTIVE app will be considered as the finalised version, concluding the research and development in the context of the PROACTIVE project.

## CONCLUSION

This work-in-progress paper presents the preliminary results from a questionnaire on the usability and usefulness of the PROACTIVE CBRNe disaster app, filled in by observers who tested the app during a field training exercise. Overall, observers felt that the app is slightly usable and slightly useful. Their constructive qualitative feedback will be used to improve the app, which will then be tested in an iterative manner in two more field training exercises.

When the project is completed, the PROACTIVE CBRNe app is expected to fill the gap in a lack of citizen oriented CBRNe disaster apps available on the market today. It will be in line with both civil society and CBRNe practitioner's expectations thanks to the co-creation process and should provide the opportunity to minimise the wider "accessibility gap" in emergency management.

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## REFERENCES

Bossu, R., Roussel, F., Fallou, L., Landès, M., Steed, R., Mazet-Roux, G., Dupont, A., Frobert, L., & Petersen, L. (2018). LastQuake: From rapid information to global seismic risk reduction. International Journal of Disaster Risk Reduction 28, 32-42. doi: 10.1016/j.ijdrr.2018.02.024.

Carbon, D., Arnold, A., Siemens, M., & Görgen, T. (2021). Common approaches between the vulnerable members of the civil society. Deliverable 3.4 of the PROACTIVE project. https://proactive-h2020.eu/wp-content/uploads/2021/03/PROACTIVE_20210226_D3.4_V5_DHPol_Common-approaches-civil-society.pdf

Carbon, D., Arnold, A., Wüller, C., Görgen, T., Godwin, T., Hale, N., Kelly, D., Marsh, I., Petersen, L., Havarneanu, G., Dennis, A., Carter, H., Weston, D., McCrone, N. & Zamorano, M. Report on the first exercise and evaluation workshop. Delierable 6.3 of the PROACTIVE project. https://proactive-h2020.eu/wp-content/uploads/2022/07/PROACTIVE_20220630_D6.3_V4_DHPol_Dortmund-Field-Exercise.pdf

Connell, B. R., Jones, M., Mace, R., Mueller, J., Mullick, A., Ostroff, E.,Sanford, J., Steinfeld, E., Story,M., & Vanderheiden, G. (1997). The Principals of Universal Design. NC State University, The Center for Universal Design.

Dallo, I. & Marti, M. (2021). Why should I use a multi-hazard app? Assessing the public's information needs and app feature preferences in a participatory process. International Journal of Disaster Risk Reduction 57 (2021), 102197–102197. Issue November 2020. https://doi.org/10.1016/j.ijdrr.2021.102197

European Commission (2019). Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services (Text with EEA relevance), OJ L 151, 7.6.2019.

Gavel, A., Kroupa, T., Navrátilová, L., Setnička, M., Clutterbuck, L., Petersen, L., Havârneanu, G., & Arnold, A. (2021). Recommendations on how to adapt SOPs and tools. *Deliverable 2.4 of the PROACTIVE project*. https://proactive-h2020.eu/wp-content/uploads/2021/03/PROACTIVE_20210228_D2.4_V5_PPI_Recommendations-on-how-to-adapt-SOPs-and-tools.pdf

Gjøsæter, T., Radianti, J., & Chen, W. (2019). Understanding Situational Disabilities and Situational Awareness in Disasters. In Z. Franco, J. J. González, & J. H. Canós (Eds.), Proceedings of the 16th International Conference on Information Systems for Crisis Response And Management. Valencia, Spain: Iscram.

Gjøsæter, J, Radianti, J., & Chen, W. (2021). Universal Design of ICT for Emergency Management from Stakeholders' Perspective - A Systematic Literature Review. Information Systems Frontiers. doi: 10.1007/s10796-020-10084-7.

Hall, C., Weston, D., Long, F., O'Sullivan, F., Amlôt, R., & Carter, H. (2020). Guidelines and recommendations for mitigation and management of CBRNe terrorism. Deliverable D1.3 of the PROACTIVE project. https://proactive-h2020.eu/wp-content/uploads/2021/04/PROACTIVE_20210315_D1.3_V5_PHE_Guidelines-and-Recommendations_revised.pdf

Haunschild, J., Kaufhold, M.-A., Reuter, C. Perceptions and Use of Warning Apps – Did Recent Crises Lead to Changes in Germany? In Mensch und Computer 2022 (MuC '22), September 4–7, 2022, Darmstadt, Germany. ACM, New York, NY, USA, 16 pages. Doi: 10.1145/3543758.3543770

ISO (2013). *Societal security — Guidelines for exercises* (ISO Standard 22398:2013. International Organization for Standardization. https://www.iso.org/obp/ui/#iso:std:iso:22398:ed-1:v1:en.

Kaufhold, M.-A., Haunschild, J., & Reuter, C. (2020). Warning the Public: A Survey on Attitudes, Expectations and Use of Mobile Crisis Apps in Germany. In Proceedings of the 28th European Conference on Information Systems (ECIS), An Online AIS Conference, June 15-17, 2020. https://aisel.aisnet.org/ecis2020_rp/84

Petersen, L, Fallou, L., Reilly, P. & Serafinelli, E. (2020) Public expectations of critical infrastructure operators in times of crisis, Sustainable and Resilient Infrastructure, 5:1-2, 62-77, doi: 10.1080/23789689.2018.1469358

Petersen, L., Havarneanu, G., Markarian, G. & McCrone, N. (2019). CBRNe and vulnerable citizens: co-creating an app for that. Proceedings of the 2019 International Conference on Information and Communication Technologies for Disaster Management (ICT-DM), Paris, France, 2019, pp. 1-4, doi: 10.1109/ICT-DM47966.2019.9032967.

Petersen, L., Havarneanu, G., McCrone, N., Markarian, G. & Kolev, G. (2021). Universal Design & the

PROACTIVE project CBRNe app. In Anouck Adrot, Rob Grace, Kathleen Moore, & Christopher W. Zobel (Eds.), ISCRAM 2021 Conference Proceedings – 18th International Conference on Information Systems for Crisis Response and Management (pp. 959–966). Blacksburg, VA (USA): Virginia Tech. https://idl.iscram.org/files/laurapetersen/2021/2388_LauraPetersen_etal2021.pdf

Petersen, L., Havarneanu, G., McCrone, N., Markarian, G., Burlin, Å., Johansson, P-E. (2022). CBRNe, a universally designed app for that? In Hedi Karray, Antonio De Nicola, Nada Matta, Hemant Purohit (Eds.), ISCRAM 2022 Conference Proceedings – 19th International Conference on Information Systems for Crisis Response and Management. Tarbes, France.
https://idl.iscram.org/files/laurapetersen/2022/2459_LauraPetersen_etal2022.pdf

Petersen, L., Havarneanu, G., Markarian, G. & McCrone, N. (2023). Practitioner Perspectives of the PROACTIVE CBRNe Disaster App. In J. Radianti, I. Dokas, N. LaLone, D. Khazanchi, eds., ISCRAM 2023 Conference Proceedings – 20th International Conference on Information Systems for Crisis Response and Management (pp. 13 – 19). Omaha, Nebraska, USA: University of Nebraska at Omaha.
http://dx.doi.org/10.59297/HVJN6870

Radianti, J., Gjøsæter, J, & Chen, W. (2017). Universal Design of Information Sharing Tools for Disaster Risk Reduction. In: Murayama Y., Velev D., Zlateva P. (eds) Information Technology in Disaster Risk Reduction. ITDRR 2017. IFIP Advances in Information and Communication Technology, vol 516. Springer, Cham. doi: 10.1007/978-3-030-18293-9_8

Steelman, T. A., McCaffrey, S. M., Velez, A. L. K., & Briefel, J. A. (2014). What information do people use, trust, and find useful during a disaster? Evidence from five large wildfires. Natural Hazards, 76(1), 615–634. doi:10.1007/s11069-014-1512-x

Tan, M. L., Prasanna, R., Stock, K., Doyle, E. E. H., Leonard, G., & Johnston, D. (2020). Understanding end-users' perspectives: Towards developing usability guidelines for disaster apps. Progress in Disaster Science, 7. https://doi.org/10.1016/j.pdisas.2020.100118.