Proceedings of the 35th European Safety and Reliability & the 33rd Society for Risk Analysis Europe Conference
Edited by Eirik Bjorheim Abrahamsen, Terje Aven, Frederic Bouder, Roger Flage, Marja Ylönen
 Published by Research Publishing, Singapore.
doi: 10.3850/978-981-94-3281-3_ESREL-SRA-E2025-P1730-cd

Emergency preparedness analysis: method for analysing and assessing emergency preparedness

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Establishing emergency preparedness should be a systematic process aimed at determining suitable emergency preparedness measures based on the existing risk. This paper presents a new method for analysing and assessing emergency preparedness, using the risk analysis as a starting point. The suggested method thus focuses on identifying emergency situations, analysing emergency preparedness arrangements, and evaluating emergency preparedness solutions, in addition to deciding the context prior to the analysis and implementing the solutions afterwords. By using the method, an organisation can scale their response arrangement and the necessary activities to cope with the manifested risk at hand, in addition to review the effectiveness of their emergency response procedures in respect of a given incident scenario. An examination of recent emergency preparedness analyses shows that the suggested method for EPA appears to be promising and useful.

Keywords: Emergency preparedness analysis, emergency preparedness assessment, preparedness planning, EPA.

1. Introduction

Establishing emergency preparedness should be a systematic process aimed at establishing suitable emergency preparedness measures based on the existing risk. Traditionally, emergency decision-makers depend mainly on their personal experience and subjective judgement when deciding whether the quantity, quality and type of response resources are fit for purpose and can meet the demands of emergencies (Wenmao et al., 2012). Correspondingly, Njå & Vastveit (2016) show that emergency plans in Norwegian municipalities only to a varying degree is related to risk analyses. This was also the case for the COVID-19 pandemic, as the government and about a fifth of the municipalities in Norway was not prepared, despite *pandemic* being the scenario with highest risk in national risk assessments (NOU 2021:6).

The Norwegian oil and gas industry, however, are required to use emergency preparedness analyses when dimensioning the emergency response arrangements for installations and operations (Styringsforskriften, 2010), with NORSOK Z-013 as guiding standard (Standards Norway, 2024). This strong focus on emergency preparedness offshore have contributed to reduce and establish a low risk level for employees in the oil and gas industry and the absence of major accidents (Vinnem, 2011). Lately, other sectors have introduced requirements for emergency preparedness analysis (e.g. Brann- og redningsvesenforskriften, 2021; Sikringsforskriften, 2022), but a generic method for emergency preparedness analysis is still missing.

In this paper, we present a new generic method for analysing and assessing emergency preparedness. Our method for emergency preparedness assessment (EPA) is based on the method for risk assessment in ISO 31000 (Standard Norge, 2018), and focus on identifying emergency situations, analysing emergency

preparedness arrangements, and evaluating emergency preparedness solutions, in addition to deciding the context prior to the analysis and implementing the solutions afterwords. Consequently, this EPA method uses the risk analysis as a starting point and guide how organisations can scale the response arrangement and the necessary activities to cope with manifested risk at hand. EPAs can also help organisations review the effectiveness of their emergency response procedures in respect of a given incident scenario. Furthermore, the EPA method we present is generic, as it can be used across different sectors and to assess preparedness for various contingencies (incidents, emergencies, crisis, and disasters). Our method for EPA is in accordance with, and builds on, previously developed methods (Eriksen et al., 2021; Njå et al., 2020; Rake & Sommer, 2018; Sommer et al., 2018). In addition, the presented method has been used to develop the new generic Norwegian standard for EPA: *NS 5840:2024 Beredskapsvurdering*.

In the following, we first describe our theoretical foundation on emergency preparedness, focusing on preparedness planning and risk assessment. Then, we present our method for analysing and assessing emergency preparedness. Finally, we present a mapping of emergency preparedness analyses carried out in different sectors, to examine whether recent emergency preparedness analyses are in accordance with newer research on risk and emergency preparedness as presented in our suggested method. Our research question has thus been: *How to use a scientific-based method for preparedness assessment to define solutions and dimension emergency preparedness?*

2. Emergency preparedness

Emergencies can be seen as "unforeseen but predictable, narrow-scope incidents that regularly occur" (Perry & Lindell, 2007, p. 29), or more broadly defined as "an imminent or actual event that threatens people, property or the environment and which requires a co-ordinated and rapid response" (Alexander, 2005, p. 159). To being able to respond to such incidents, *preparedness*, understood as "a state of readiness to respond to a disaster, crisis, or any other type of emergency situation" (Haddow et al., 2024, p. 646), is crucial. Planning is here the core activity, as this is the "process that analyses specific potential events or emerging situations and establishes arrangements such as capacity- and capability-building in advance, in order to enable timely, effective and appropriate responses to such events and situations" (Pursiainen, 2018, p. 72). Preparedness planning is thus a cyclical process, as illustrated in figure 1.

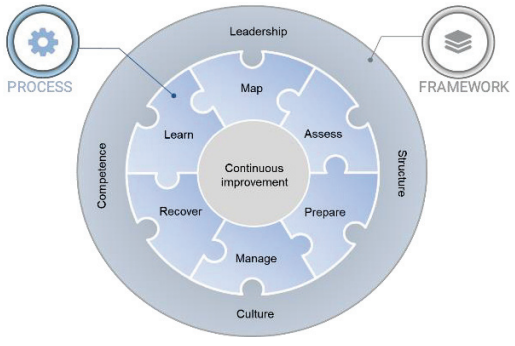

Fig. 1. Model for contingency (Eriksen et al., 2021).

2.1 Preparedness planning

A prerequisite for all emergency preparedness planning is accurate knowledge of the threat and of likely human responses (Perry & Lindell, 2003). Hazard identification and risk assessment is thus the crucial first step that provide knowledge about the threats that may turn into an emergency situation (Drennan et al., 2024; Haddow et al., 2024; Pursiainen, 2018).

Based on the situations that may emerge, assessing and providing the necessary capacities needed to manage the emergency situations is the next step. This is a question about resources, both physical resources in the form of equipment, technologies, and supplies (Haddow et al., 2024), and monetary resources such as time, money, and institutional and legal solutions, strategies and policies (Pursiainen, 2018). To find out what capacities will be necessary, Drennan et al. (2024) emphasise the importance of creating probable scenarios, which is "a fictional depiction of the impact of a probable threat that allows planners to think about the practical implications of a crisis response" (p. 117). This, they argue, can help identify planning assumptions and resources needed. Hence, a capacity analysis (Pursiainen, 2018) or vulnerability assessment that include the measurement of individual and organisational capacity (Haddow et al., 2024) is needed.

Thereafter, when the required capacities are revealed, plans for how to respond must be developed. This should contribute to "participants become party to a common understanding of what will be done, by whom, at what point in time, under whose authority, with what resources, and to what end" (Haddow et al., 2024, p. 198). Hence, defining responsibilities, roles and tasks are essential (Pursiainen, 2018), the same is addressing inter-organisational coordination (Perry & Lindell, 2003). In general, Drennan et al. (2024) state that contingency plans tend to share the following common features: *activation criteria* for when a response should be triggered, *objectives* for the organisation's response, *response processes* for the specific objectives, *decision making authority* to those responding, and *resources* allocated to the response.

Finally, the plan must be implemented and tested. Implementation includes both acquisition of resources and training of response personnel (Haddow et al., 2024). The training aims to develop the skills and knowledge needed, thus being important for building the necessary capabilities to manage emergencies (Pursiainen, 2018). Exercises, then, are used to test the plan, by simulating emergency situations and responses (Drennan et al., 2024). A comprehensive exercise program should include drills, table-top exercises, functional exercises, and full-scale exercises (Coppola, 2020). If the evaluation of exercises reveals areas of improvement, this should be followed up and improved.

The research on emergency management and preparedness planning, however, do not contribute on generic method for analysing and assessing emergency preparedness. Methods for risk assessment can therefore provide guidance on how to methodologically approach the assessment of emergency preparedness.

2.2 Risk assessment

Risk can be defined as "the two-dimensional combination of the consequences C of the activity (with respect to something that humans value) and associated uncertainty about C" (Aven, 2020, p. 267). Risk assessment, then, is a "systematic process to comprehend the nature of risk, express and evaluate risk, with the available knowledge" (Aven, 2020, p. 270). To do this, the assessment process needs to address the following key aspects (Aven & Thekdi, 2025):

- What can happen ('go wrong')
- Link risk events to consequences
- Assess uncertainty
- Evaluate the risk

The assessment can be qualitative or quantitative (Aven, 2014), typically characterizing the risk by assessing the likelihood of events occurring and their consequences (Lundgren & McMakin, 2009; Aven & Renn, 2010). Newer research on risk, however, emphasizes the importance of uncertainty in risk assessment (Aven, 2016, 2017, 2020), where it can be understood as a lack of knowledge about events and the consequences of these (Flage & Aven, 2009; Aven & Zio, 2018). When assessing the strength of knowledge, the following aspects should be taken into consideration (Aven, 2017; Flage & Aven, 2009): (i) the reasonability of the assumptions made, (ii) the amount and relevancy of data/information, (iii) the degree of agreement among experts, (iv) the degree to which the phenomena involved are understood and accurate models exist, and (v) the degree to which the knowledge has been thoroughly examined.

When a company or an authority is going to assess the risk associated with their activity, they normally do it as part of their risk management process. This process is broken down by Aven (2020) into the following steps (which he points out are in line with standards such as ISO 31000 and most risk analysis textbooks; see e.g. Meyer and Reniers (2013) and Aven (2015)): (i) establish the context to define the purpose of the risk management activities and specify goals and criteria, (ii) identify situations and events that can affect the activity considered and objectives defined, (iii) conduct cause and consequences analysis of these events, (iv) make judgements of the likelihood of the events and their consequences and establish a risk description or characterization, (v) evaluate risk to judge the significance of the risk, and (vi) risk treatment (see also Aven & Thekdi, 2025).

Risk management, thus, covers all measures and activities carried out to manage and govern risk (Aven, 2020). In essence, emergency preparedness is part of the risk management process. However, the literature on risk analysis and risk assessment do not cover the core activities in preparedness planning (as described in chapter 2.1).

3. Emergency preparedness analysis

Emergency preparedness analysis is a systematic process for identifying, understanding, and describing emergency preparedness solutions and the associated performance requirements. This, we suggest, can be done by following the model for EPA. Before we present the model, we describe how to approach goals and requirements for emergency preparedness.

3.1 Goals and requirements

To assess the emergency preparedness, it is necessary to have something to assess the preparedness against. Assessment criteria is therefore essential. This is criteria for what is sufficient preparedness, which need to be defined and agreed upon prior to the emergency preparedness analysis. An approach to define what is *sufficient* when it comes to emergency preparedness, is to define goals and performance requirements for an acceptable level of preparedness based on regulatory requirements and other expectations. The relationship between goals and requirements are illustrated in figure 2.

Fig. 2. The relationship between goals and requirements for emergency preparedness.

Regulatory requirements and other expectations to preparedness can be found in laws and regulations, in stakeholders' values and expectation, and in organisations' normative and governing documents. Based on these expectations, goals for the emergency preparedness can be defines.

Evaluation criteria is the criterions that should be guiding when comparing and evaluating different preparedness solutions. Typical evaluation criteria can be compliance to rules and regulations, effect on risk, achievement of objectives, economy, quality (effect, robustness, and reliability), and HSE for the response personnel (health, safety and environment).

Performance requirements specify the qualities that the preparedness solutions should have. These requirements should contribute to achieve the goals for the emergency preparedness. The performance requirements will thus be specifications of the preparedness solutions' properties such as functionality, usability, effectiveness, capacity, accomplishment, reliability, and robustness. These requirements should also be specific, measurable, achievable, relevant, and time-bound (S.M.A.R.T.).

When the performance requirements for the preparedness solutions are defined and decided upon, it must be established routines that ensures and controls that the requirements are met. Establishing requirements for quality assurance of the sufficient emergency preparedness, which are in accordance with the performance requirements, will be advantageous in this regard.

3.2 Emergency preparedness assessment

The purpose of EPA is to enable risk and knowledge-based decisions about emergency preparedness solutions to implement. This includes identifying emergency situations to plan for, analyse the different parts of the emergency preparedness arrangement necessary for managing the situations, and evaluate which emergency preparedness solutions are most suitable according to given criteria. To do this, some supportive activities would be useful. The process for EPA is illustrated in figure 3.

Fig. 3. Model for emergency preparedness assessment.

This model builds on the model for risk assessment in ISO 31000 (Standard Norge, 2018). EPA must be seen in relation to risk assessment, because emergency management is part of risk management. The assessment process therefore has many similarities.

3.2.1 Establish context

Before the EPA starts, the context for the assessment must be established. In risk assessments, this includes defining the purpose of the risk management activities and specify goals and criteria for the assessment process (Aven, 2020; Aven & Thekdi, 2025; ISO 31000). Correspondingly, the purpose for the emergency management activities must be defined and specific goals and evaluation criteria for the emergency preparedness arrangement must be specified. Also, the objectives for the preparedness assessment activities must be defined.

3.2.2 Identify emergency situations

The purpose of identifying emergency situations is to define which situations to prepare for, or in other words, identify which threats that may turn into an emergency situation (cf. Drennan et al., 2024; Haddow et al., 2024; Pursiainen, 2018). In risk assessment, this is about identifying what can happen in terms of what can 'go wrong' (Aven & Thekdi, 2025). In EPAs, on the other hand, this is a question about what can happen that it may be necessary to respond to and manage, or 'what to be prepared for' (cf. Haddow's et al., 2024, definition of *preparedness*). To identify emergency situations, three steps are central.

First, *specify the 'emergency preparedness area'*. This is the range of emergency situations to be prepared for. The starting point will typically be the risk description resulting from the risk assessment. In figure 4, we see a traditional risk matrix with the emergency preparedness area indicated with a frame. When specifying this area, the preferred approach should be to specify which situations *not* to include. This would normally be situations with low probability and/or low consequences, or situations that obviously will be too costly to establish emergency preparedness for. Why not to include a certain situation should also be justified.

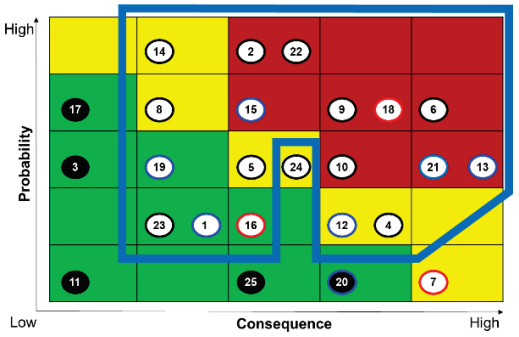

Fig. 4. Example of emergency preparedness area.

Second, *select emergency preparedness situations for analysis*. Some of the situations will require more or less identical prepared solutions, as the type of resources and competence needed will largely be the same. Such situations can therefore be grouped into categories. Table 1 shows how the situations in the emergency preparedness area in figure 4 can be categorised.

Table 1. Example of categories.

#	Emergency situation	Category
16	Leisure boat accident	Shipping accidents
8	Ferry accident	
12	Speed boat accident	
18	Cruise ship accident	
1	Road accident with leakage	Acute pollution
15	Leakage from industry	
13	Oil leakage at the coast	
19	Airborne infection	Health diseases
22	Waterborne infections	
6	Pandemic	
14	Building fire	Fires
5	Fire in department building	
2	Industrial fire	
9	Fire at nursing home	
23	Burglary and theft	Criminality
10	Hostage situation	
21	Bomb attack	
	Etc.	

When the situations are categorised, we find which situation to be representative for each category. Table 2 shows the representative emergency situations for each category in table 1.

Table 2. Example of representative emergency situations.

#	Emergency situation	Category
18	Cruise ship accident	Shipping accidents
13	Oil leakage at the coast	Acute pollution
6	Pandemic	Health diseases
9	Fire at nursing home	Fires
21	Bomb attack	Criminality

Third, *describe the selected emergency preparedness situations*. The purpose is to ensure a shared understanding of the situation that is going to be analysed. This should include a description of the potential scenario that may unfold, in addition to principles for response, assumptions, and uncertainty.

3.2.3 Analyse emergency preparedness

Analysing emergency preparedness involve a detailed analysis of the selected emergency preparedness situations' potential scenario to identify suitable preparedness solutions and associated emergency performance requirements. This corresponds to the part of risk analyses that links events to consequences by analysing why and how the identified events could result in negative or positive consequences (Aven & Thekdi, 2025). Related to emergency preparedness, this is about analysing which capacities and resources will be needed to ensure a response that reduces the consequences of the situation as much as possible (cf. Drennan et al., 2024; Haddow et al., 2024; Pursiainen, 2018). Depending on the purpose of the emergency preparedness analysis, the analysis of the selected emergency preparedness situations can cover themes such as organisation, resources, competence, cooperation, HSE, response strategy and tactics, barriers, stakeholders and communication.

However, independent of the themes, the analysis must be structured and define performance requirements and assumptions. Performance requirements will typically be specifications of the preparedness solutions' properties (see chapter 3.1). Assumptions, then, is the beliefs and expectations that form the basis of the requirements, and the conditions necessary to meet the requirements in real life. Clarifying the assumptions will thus be a step to understand the knowledge and consequently the uncertainty that the emergency preparedness analysis is based on (cf. Aven, 2017; Flage & Aven, 2009).

3.2.4 Evaluate preparedness solutions

Evaluating preparedness solutions should be done to find the most suitable solutions. In risk analyses, cost-benefit analysis is the preferred method for evaluation (Aven, 2020; Aven & Thekdi, 2025). When it comes to emergency preparedness, however, cost and benefits can be a part of the evaluation criteria or a part of the decision process after the fulfilment of the EPA. Given the range of relevant evaluation criteria, as described in chapter 3.1, the evaluation should consider both financial aspects and practical advantages and disadvantages.

Furthermore, uncertainty must be taken into consideration, as there will be uncertainty in all parts of the EPA. Especially, it will be uncertainty associated with the identification of emergency situations, the scenario description of the selected emergency preparedness situations, and the analysis of capacities and resources needed to reduce the consequences of the situations. In essence, this is a question of knowledge about events and the consequences of these (cf. Flage & Aven, 2009; Aven & Zio, 2018), where the degree of uncertainty can be assessed as high, medium or low according to the strength of knowledge (and for instance indicated with red, blue, and black, respectively, in the risk matrix, as illustrated in figure 4).

3.2.5 Implement preparedness solution

Implementing the preparedness solution includes acquisition of necessary equipment and other resources, development or revision of contingency plans, training of personnel, and exercises to test the decided emergency preparedness solution.

3.2.6 Communication and consultation

A successful EPA requires involvement of relevant stakeholders and access to necessary information. It is therefore important to continuously, throughout the entire assessment process, communicate and consult with relevant actors and stakeholders.

3.2.7 Monitoring and review

Monitoring and review aim to ensure that all the activities in the EPA process are planned, carried out, and followed up according to required quality standards. Methods for quality assurance in project work should with advantage be used.

4. Mapping of emergency preparedness analyses

To examine whether recent emergency preparedness analyses are in accordance with newer research on risk and emergency preparedness, we have studied a sample of seven emergency preparedness analyses carried out in different sectors:

A. Municipalities in the Stavanger region.
B. The ambulance service in mid-Norway.
C. Eastern Agder fire department.
D. Fannefjord tunnel, Fv. 64.
E. Ljoteli tunnel, Fv. 53.
F. E39 Storehaugen - Førde, road and tunnel.
G. Nordøyvegen, tunnels, Fv. 659.

Our mapping is done as a document study, where we have examined whether the analyses cover the different parts of the model for EPA presented in chapter 3, namely Context, Identification, Analysing, Evaluating, and Implementation.

All of the analyses have defined the purpose and scope for their analyses, in addition to describe the methods used and process for the analyses. For the most part, the goals for the preparedness are well defined, and the risk description that the analyses are based on are included or presumably covered in a separate risk analysis. However, evaluation criteria to guide the comparison and evaluation of different preparedness solutions are absent (with some exceptions in analysis A and B).

Identification of emergency situations are covered, as all of the analyses for the most part specify the emergency preparedness area, select emergency preparedness situations for analysis, and describe these situations.

Analysing emergency preparedness is also mainly covered. Themes and content are well defined, and requirements for the preparedness are clearly stated in most of the analyses (A, B, D, F and G). The assumptions, however, are only partially stated and accounted for.

Evaluating preparedness solutions are practically absent, as only a few of the analyses (A, B and F) are evaluating their suggested preparedness solutions to some criteria. Advantages and disadvantages are only assessed in two of the analyses (B and F). Uncertainty is not taken into consideration in any way (with some exceptions in B), making it difficult to consider the strength of knowledge the assessments are based on and the validity of the suggested preparedness solutions.

Implementation of the preparedness solutions are well described, as the suggested solutions and proposed measures are clearly presented. However, a clear comparison of the suggested preparedness solutions with the existing preparedness arrangements, in the form of a GAP analysis, is only partially included.

Overall, we see that the analyses that have had a broad involvement in the process have the most comprehensive assessments. An interview with the Eastern Agder fire department confirms the importance of involvement. They also emphasise the use of a scenario-based approach, as many of the analysed scenarios have happened in real life as similar incidents, where these have been managed successfully with the preparedness solutions that was suggested in their emergency preparedness analysis.

Conclusion

The suggested method for EPA appears to be a promising and useful approach for analysing and assessing emergency preparedness. Especially, the method helps define which situations to prepare for and thus identify suitable preparedness solutions and associated emergency performance requirements, resulting from scenario-based analyses according to the existing risk. However, considerations of uncertainty and strength of knowledge appears to be missing in previous EPAs across sectors. Using our suggested method for EPA will thus ensure that assessment of uncertainty is part of the process. Furthermore, using the EPA method is resource demanding and time consuming, and there is a need for competence and broad involvement in the process for the result to be satisfactorily. A future, more detailed analysis of different EPAs can further expand knowledge of good practice for performing EPAs as part of emergency preparedness.

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