Emergency preparedness analysis

Planning the emergency response arrangements for the fire and rescue service

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Keywords: emergency preparedness analysis, fire service, emergency planning, emergency response arrangement, emergency decision-making

ABSTRACT

An adequate response to fires and other emergencies requires that the fire service need to dimension its response resources to existing risks. This article examines how the emergency preparedness analysis (EPA) approach can be used to improve emergency planning in the fire services by studying how EPA is used to scale two intermunicipal fire and rescue services (IMFRS). The article concludes that fire and rescue services will benefit from using an EPA when scaling their emergency response arrangements. However, for the recommendations that follow from the EPA to be respected and accepted, the firefighters and decision-makers must be involved in the EPA process, and the recommendations must be a major part of the rationale for the decision.

INTRODUCTION

To mount an adequate response to fires and other emergencies, the fire services must adapt their response resources to existing risks. Traditionally, fire departments and municipalities have done this on the basis of a risk and vulnerability analysis combined with experience. However, this approach to emergency planning has shortcomings. Njå and Vastveit have shown that emergency plans in Norwegian municipalities are related to risk analyses to varying degrees [1]. The Norwegian Directorate for Civil Protection (DSB) has come to the same conclusion, stating that it is often difficult to see the connection between risk analyses and the scaling of fire and rescue services [2]. Generally, 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 [3].

In contrast, in the Norwegian oil and gas industry, it is mandatory to use emergency preparedness analyses when scaling the emergency response arrangements for installations and operations [4]. This strong focus on emergency preparedness offshore has contributed to a low level of risk for employees in the oil and gas industry and the absence of major accidents [5].

The DSB suggests that it be required, by regulation, that the Norwegian fire and rescue services start using emergency preparedness analysis to determine which incidents and accidents it must able to deal with and accordingly how to organise, equip and staff its services and develop the necessary competences [2].

In this article, we examine how the emergency preparedness analysis (EPA) approach can be used to improve emergency planning in the fire services. We will discuss how an emergency preparedness analysis can be used as a tool in the scaling of fire services' emergency response arrangements. The findings, and the tool, can be used not only in the fire services but also when dimensioning emergency response arrangements in general.

EMERGENCY PLANNING BASED ON EMERGENCY PREPAREDNESS ANALYSIS

The emergency preparedness analysis approach was developed by Rake and Sommer [6] and is based on the oil and gas industry's approach [4] as well as the work of Aven et al. [7].

Establishing emergency preparedness is a systematic process aimed at establishing suitable emergency preparedness measures by using risk analysis and emergency preparedness analysis. The process involves identifying, planning and implementing described and defined risk scenarios in relation to identified hazards and accidents. It also includes establishing the functional requirements of emergency preparedness and identifying emergency preparedness measures [4].

Figure 1 describes emergency preparedness as an ongoing process consisting of six discrete steps.

Step 1: Set the objectives; for instance, the fire department's overall goals are set by the board. Describe legal requirements, such as dimension criteria, described in law, regulations and/or guidelines, that affect preparedness and the expected ability to cope as required. An example of a local fire service requirement is to have rescue diver preparedness, and an example of a legal requirement is that the first responders to a fire at a hospital shall be on scene within 10 minutes of call-out.

Figure 1: Emergency preparedness process

Step 2: A systematic identification and description of risks is needed. The risk analysis may cover several types of analyses that will all assess the causes of accidents and the consequences of possible accidental events. Examples of such analyses are HAZOP and risk and vulnerability analyses. The latter involve quantifying the probabilities and consequences of accidental events when the risks occur. This quantification allows for a comparison and prioritisation of the identified risks, for instance by using risk acceptance criteria. DSB recommends that the fire services employ risk and vulnerability analysis to identify and quantify the risks that the fire service can meet. A risk image is created and describes the risks at hand and to be dealt with.

Step 3: Preparation of the emergency preparedness analysis by analysing the risks from step 2. The scaling risks are called 'defined situations'. The functional requirements of coping successfully are described. This step is the focus of this paper and will be elaborated on later.

Step 4: Preparation of the necessary emergency arrangements and plans. This can take the form of a description of the emergency organisation or special emergency plans, for instance, forest fire plans. Other plans, such as training and exercise plans and investment plans, can also be prepared as part of this step.

Step 5: Implementation of the plans resulting from step 4, which, for instance, can include building a new fire station, purchasing equipment, restructuring, or training the responders according to the plans or introducing new exercise activities. The planned organisation must be established, trained and exercised in order to handle occurrences of the identified and dimensioning risk situations, for instance, a train derailment with subsequent fire.

Step 6: Implementation and experience of the exercises and accident responses are followed by evaluation and update. Changes may be necessary, with the aim of improving the plans and emergency arrangements.

STUDY APPROACH

As mentioned, emergency planning in the government sector has shortcomings. In the municipalities, the principles of risk-based planning are almost non-existent, and the notions of 'dimensioning risks' and 'defined situations' are entirely unknown [1].

The railway sector faces similar challenges. The Norwegian Railway Authority (NRA) conducts inspections and audits to ensure that railway companies operate in accordance with legal requirements regarding safety and security. In 2018, the NRA revealed important shortcomings in relation to emergency preparedness in the railway sector [8], such as absent emergency analysis and a lack of defined situations, the existence of only a few functional demands, emergency preparedness only including normal situations when staffing and equipment arrangements are in order, vacancies not analysed or described, and emergency plans not updated or adapted to actual daily operations.

In this study, we examined how an emergency preparedness analysis is used to dimension two intermunicipal fire and rescue services (IMFRS). IMFRS-I is located in western Norway. This service covers nine municipalities and more than 100,000 inhabitants and consists of both full-time and part-time firefighters. IMFRS-II is in southern Norway. The fire service covers seven municipalities, 70,000 inhabitants, eight fire stations and 190 employees, including both full-time and part-time firefighters. To study the use of the analysis, we participated in the work and followed the process in both IMFRSs.

RESULTS

Premises for the EPA

The aim of both the EPAs was to dimension the emergency preparedness arrangement for the entire geographical area for the fire service is responsible and the fires and other accidents that they must be prepared to manage within this area. In IMFRS-I, the EPA was carried out during the first quarter of 2018 by a working group consisting of representatives from the original fire services in each of the nine municipalities. IMFRS-II finalised its EPA in December 2018. Their common mandate was to conduct an EPA based on legal demands and risk assessments, in addition to building on previous political decisions and the partnership agreement for the IMFRS.

Before the EPA was started on, the existing risk analyses in both fire services was revised. The service analysed 43 and 49 risk scenarios, respectively. The revisions showed that the main risks within the IMFRS-I area was related to:

- Traffic, both passenger traffic and heavy cargo transport.
- Water, whether coastlines, fjords or rivers.
- Industrial plants and installations.
- Areas of densely placed old wooden houses.
- Woodland areas and forests.

The main risks in the IMFRS-II area were similar to those in the IMFRS-I area, and included traffic accidents and areas containing dense stands of old, stately wooden houses. However, it also included vulnerable population groups in the municipalities, sizeable snowfalls, a fire inside the hospital, and the fire service's emergency medical assignments.

Results of the EPA

The risk analysis provided input to the EPA, where the identified risks were used to define risk scenarios within categories of incidents; see table 1:

Table 1: Dimensioning Risk scenarios

#	IMFRS-I	IMFRS-II
1	Dangerous goods and acute contamination	Traffic accident in a tunnel, fire and leakage of chemicals
2	Ongoing life-threatening violence	Fire in a building with hostile residents
3	Fire at sea (boats)	Fire at sea (boats) and fuel leakage
4	Fire in buildings	Fire in dense stands of old, stately wooden houses
5	Industrial fire	-
6	Forest fire	-
7	Natural disaster/extreme weather	-
8	Person in water	Person in a river
9	Traffic and transportation accident	Train accident. Derailment in steep terrain
10	Simultaneous incidents	
11	-	Fire at a mall
12	-	Fire at the hospital

As is apparent from the table, the number of risk scenarios is limited, and it is recommended that planners not exceed 10 scenarios. Additional scenarios will complicate the EPA. It is also worth noting that the scenarios are of similar categories. The principal difference is that IMFRS-I has 10 categories, while IMFRS-II has eight. An interesting observation is that IMFRS-I has the category 'Forest fire', while this category is missing from IMFRS-II. IMFRS-II is in a wooded area with extensive logging and has experienced a number of forest fires, while IMFRS-I has very sparsely forested areas but hilly, rocky terrain, which makes the combating of bush fires complicated and time consuming.

Between 1 and 11 risk scenarios were defined for each IMFRS-I category. Furthermore, because the entire IMFRS-I area with its nine municipalities contains a total of 21 densely populated areas, it was necessary to establish which scenarios ought to be dimensioning for which areas. Table 2 shows the dimensioning risk scenarios and respective areas for the category 'Fire in buildings'.

IMFRS-II adopted a different strategy. They assessed the transferability of each scenario to other sites and fire stations in the region. Each risk scenario was then analysed in detail to identify performance and resource requirements (IMFRS-II). This approach also makes it possible to identify the competence requirements.

Table 2: Dimensioning Risk scenarios for fire in buildings (IMFRS-I)

#	Scenario	Area
I	Fully developed fire within a standalone fire cell, without people inside the building.	All (especially G and U)
II	Fire in part of a fire cell (housing unit/dwelling), with one or more persons inside the building and risk of fire spreading.	All, except G and U
III	Fully developed fire in part of building with many persons (e.g., hotels, nursing homes, hospitals).	All, except G and U
IV	Fire in buildings higher than three floors, with people inside the building and shortage of emergency exits/escape routes.	A
V	Fully developed fire in a fire cell (housing unit/dwelling) in an area with dense stands of old wooden houses	A, C and N
VI	Fire in part of a large agricultural building/farm outbuilding with livestock/farm animals.	C, D, E, I, J, K, L, M, N, O, P, Q and R
VII	Fire in industrial building with high fire load and long distances (warehouses, storage buildings, lumberyards, etc.).	All, except G, L and U
VIII	Fire at process plant with liquefied natural gas (LNG), with pipelines exposed to heat.	D, E and J
IX	Limited fire at a power station, with people inside the building.	O and S
X	Fire in a subsea road tunnel during the building phase	M

Figure 2 shows the analysis of dimensioning risk scenario V for IMFRS-I. A split in emergency phases will facilitate the following analysis. This is shown in the left-hand column. The most appropriate split appears to use three to five phases.

Dimensioning Risk scenario:	**Fully developed fire in a fire cell (housing unit/dwelling) in an area with dense stands of old wooden houses**
Expected handling:	**Evacuate residents and limit the fire spread to the fire cell (housing unit/dwelling)**

Response phase	Needs and measures	Time to execution	Personnel	Equipment
Alarm and mobilisation	–	20 minutes	–	–
Arrival on scene/ initial response	Command and start of initial response (organise the resources and take action to limit the fire)	+0.5 minutes	*Personnel:* Crew manager Fire engine driver	*Equipment:* Small, fast-moving car with extinguishing equipment
	Start of main response (rescue and firefighting)	+4 minutes	5 firefighters	Firetruck
Rescue and damage control	Additional firefighters for support	+15 minutes	*Personnel in addition to initial response:* 10 firefighters	*Equipment in addition to initial response:* Firetruck and transport unit
	Incident command	+0 minutes	Incident commander	Command vehicle
Normalisation	Supply equipment	+80 minutes	*Personnel in addition to rescue and damage control phase:* 1 firefighter	*Equipment in addition to rescue and damage control phase:* Logistics truck with fire protection clothing and smoke diver equipment
	Extinguish the fire and secure the scene	4 hours	2 firefighters	Firetruck or water tank truck for extinguishing
	Conserve property	6 hours	2 fire-fighters	Property conservation truck

Necessary equipment		
#	**Type of equipment**	**Time (min)**
1	Small, fast-moving car with extinguishing equipment	20
1	Fire engine	20
1	Fire engine	35
1	Transport unit	35
1	Command vehicle	35
1	Logistics truck	110
1	Fire engine or water tank truck	110
1	Property conservation truck	110

Necessary personnel		
#	**Type of personnel**	**Time (min)**
2	Crew manager/Fire engine driver	20
5	Firefighters/ Fire engine driver	20
5	Firefighters/ Fire engine driver	35
5	Firefighters	35
1	Incident commander	35
1	Firefighter	110
2	Firefighters	110
2	Property conservation personnel	110

Figure 2: Detailed analysis of a dimensioning risk scenario, with performance and resource requirements

After all the scenarios were analysed in detail, the performance and resource requirements were summarised and systemised into requirements for the location of equipment, number of personnel, duty or response arrangements for firefighters and incident commanders, competence and training needs, and fire station structure. All of these requirements were then compared to the existing emergency response arrangement to establish what was already in place and what needed to be acquired or put in place. This gap analysis revealed a need for improvement or upgrade within all groups of requirements (table 3 sets out the results of the gap analysis for the location of equipment).

Table 3: Location of equipment (IMFRS-I)

	Area																				
Equipment	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**
Fire engine	2x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Transport unit, 4–5 persons	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Water surface rescue equipment	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Water tank truck	x		x	x				x			x	x	x		x	x				x	
Ladder truck	x			x																x	
Logistics truck	x			x												x					
Property conservation truck	x																				
Rescue diver truck	x																				
Acute contamination truck	x																				
All-terrain vehicle (ATV)	x		x	x			x	x		x						x				x	
Boat and boat trailer	x		x	x			x	x				x	x	x		x				x	x
Flood control equipment	x																				
Equipment for heavy goods vehicle rescue											x				x						

x	Requirement fulfilled	x	To be considered	x	Investment required

Implementation of the EPA results

To scale the IMFRS according to the EPA, the board of representatives (i.e., the politicians representing each of the municipalities) must decide what to do with the results of the EPA and which of the EPA's recommendations to implement. This responsibility can also be delegated, for example, to the chief fire officer, but the board will always at least be informed of the results and consequences. However, the question of the location of the main fire station in IMFRS-I was not straightforward. The EPA recommended an ideal location with reference to buildings with high fire risk: alternative 5 in municipality X (figure 3).

Figure 3: Alternative locations for the main fire station

This alternative faced opposition from the politicians in municipality Y, who did not accept this as the location of the main fire station. They had, in fact, prior to the commencement of work with the EPA, decided in their municipal area development plan that alternative 7 should be used as the location of both the fire station and the intermunicipal emergency medical service (EMS). The politicians in municipality X had already decided to incorporate the EMS, under the condition that the EMS was co-located with the main fire station (this decision, too, had been made before the work with the EPA started). In other words, the politicians in two of the municipalities had made decisions in other cases that did not harmonise with the recommendations of the EPA. Moreover, both municipalities threatened to withdraw from the entire IMFRS if the main fire station was not located on their side of the municipal border. The management of the IMFRS then conducted an analysis of the risk-reduction measures necessary in the city centre of municipality X to make it possible to locate the main fire station at alternative 7. The only acceptable solution, from a fire risk perspective, was an additional small fire station located in the city centre. The politicians in municipality Y accepted this solution, but those in municipality X did not – the politicians there found a two-fire-station solution too costly, even in light of a significantly improved level of emergency fire preparedness. The politicians in municipality X therefore decided to withdraw from the IMFRS and establish their own fire service, and the IMFRS was re-established without municipality X.

DISCUSSION AND CONCLUSION

An EPA can help improve the fire service's emergency preparedness arrangements. The EPA helps the fire service to clarify which situations they should be prepared to manage and the types of resources and competences they need. It also helps to connect the scaling of the fire and rescue service with the risk analysis – a connection that DSB in general experiences as weak [2] – thus enabling risk-based planning. IMFRS-II, for instance, included a scenario called ‘The Unexpected Accident’ and forced themselves to consider alternatives to the traditional and expected actions and ways of responding.

However, the EPA does not guarantee a ‘correct’ dimensioning scaling of the fire service – it simply provides decision support to those making decisions regarding the emergency response arrangements. Other factors, such as financial circumstances, the improved efficiency of the municipal services, the inhabitants’ sense of fire safety, and political agendas, are also of significance. To describe measures based upon the expectations (see figure 1, step 1) of different stakeholders is complicated. Nevertheless, an EPA offers better decision support than using risk scenarios that ‘only’ state what can go wrong, because the EPA gives details about what is needed in terms of resources, where they need to be located, and the costs. Moreover, it makes it easier to prioritise if the budget allocation provides less than needed, facilitating deliberate decisions about which services to cut and which dimensioning risk scenarios that the service will not be able to manage.

The proposed method of emergency preparedness analysis [6] appears to be a suitable tool for fire services when dimensioning their emergency response arrangements. The general experience of the fire service’s members who participated in the EPAs is that this kind of analysis rendered more visible and explicit what they needed to be able to respond to and what types of resources were necessary. The results of the EPA also appeared to be accepted by the responders and the fire service boards as an objective description of the needs for equipment, staffing and forms of organisation.

On the other hand, the EPA challenged the responders involved due to lack of competence and experience of similar analyses. Two main challenges were that the analysis was initially experienced as theoretical for the participants (due to new, abstract concepts) and that it was difficult for responders to free themselves from the existing emergency response arrangements and from what was seen as achievable with current budget and existing framing conditions. However, these challenges are not insurmountable. In IMFR-II, the EPA programme started with an introductory lecture and a textbook that explained the methods to be used and discussed the process and emergency challenges. The concept of EPA becomes more familiar as the level of experience with analysis increases. Risk analyses have been used for a long time in the fire service sector, and the participants were familiar with this kind of analysis. Perry and Lindell [9] pointed out that risk reduction involves an examination of the necessary actions in order to identify the resources needed to cope with the risk that has manifested, and that accurate knowledge of threats and responses is needed. The EPA seems to be a useful tool for the fire services in that regard.

As stated previously, decisions regarding the quantity, quality and type of response resources generally depend on the personal experience and subjective judgement of emergency decision-makers [3]. The responders’ personal experience and own judgement also played a significant role in the EPAs in this study, but these judgements were systemised and combined with more objective risk analyses and knowledge about fire dynamics, firefighting, rescue operations and incident command.

To conclude, fire and rescue services will benefit from using an EPA when scaling their services’ emergency response arrangements. However, the process must involve the firefighters and decision-makers. The EPA’s recommendations are a part of the decision to be made, but the recommendations must be a major part of the rationale for the decision. If not, it is unlikely that the EPA process, and its final result, will be respected and accepted.

Further research into EPA should include a study of the final conclusion of the response arrangement, the benefits, and the perceptions of the involved personnel and decision-makers. A thorough study of the experience of using the EPA as a method and the inherent process is also needed.

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