Emergency management assessment for Esbjerg Municipality

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Abstract

The purpose of this project is to assess the emergency management setup of the municipality and the fire department of Esbjerg, Denmark. Furthermore, analyze an emergency situation exercise with the municipal management team, incorporating assistance with a simulation software.

First of all, a preliminary understanding of the current emergency management setup is carried out, including legislation standards, the organizational structure, and the current emergency plans. In addition, a hypothetical emergency scenario is created, combined with the use of a simulation software, in order to assess the team's performance. Moreover, a FRAM model is created to describe outcomes based on a variability in socio-technical systems.

In conclusion, improvement can be drawn out of the emergency management performance during the exercise simulation, such as communication, response time during decision making, and solutions quality. As well as the incorporation of simulation software to aid in the training and practice exercises.

Preface

After Emergency Management course on 3rd semester of our MSc. Risk and Safety management studies, our interest into this field peaked and became interested in working more with topics of emergency management.

The report is aimed towards professionals and students with interest in emergency management in Denmark. The reader will take a look into the use of new simulation tools to analyze the emergency management on a management level.

The report is written as part of the Risk and Safety Management 4th semester master thesis at Aalborg University Esbjerg during the period of 01/09/2016 to 10/01/2017 and counts for 30 ECTS.

We would like to thank Anders Schmidt Kristensen, AAU Esbjerg, and Dewan Ashan, SDU Esbjerg for supervision of the project throughout the course.

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Furthermore we would like to thank C4i and especially Clive Morgan for providing us with a license for the simulation software EDMSIM and providing support.

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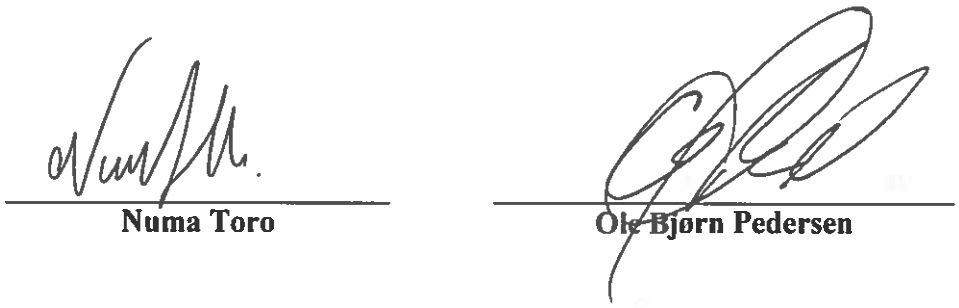
Esbjerg, January 10, 2017



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Acronyms

AAU	Aalborg University
DEMA	Danish Emergency Management Agency
DMI	Danmarks Meterologiske Institur
EDMSIM	Emergency and Disaster Management Simulation
EOC	Emergency operation center
ERCC	Emergency Response Coordination Centre
FEMA	Federal Emergency management agency ‘
GIS	Geographic information system
ICCS	Integrated Control and Command System
KL	Kommunernes Landsforening
LBS	Lokal beredskabsstab
MFRS	Municipal Fire and Rescue Services
MOD	Ministry of Defense
MSBR	Midt-og Sydsjællands Brand & Redning
NATO	North Atlantic Treaty Organization
NGO’s	Non-governmental organization
NSBV	Nordsjællands Brandvæsen
OESB	Østsjællands Beredskab
SINE	SIkkerhedsNEttet
SOK	Søvernets Operative Kommando
SVJB	Sydvestjysk Brandvæsen
TETRA	TErrestial TRunked Radio
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEA	Working Environment Agency

Contents

1

Introduction

Emergency and disaster management disciplines is in constant development. Worldwide FEMA pushed a lot of the development. Today more and more resources and effort are put into emergency management and an often mentioned saying when it comes to disaster management, is that *it is not a question of if, but when.*

When dealing with emergency management a holistic approach is needed to cover every aspect of a disaster. The emergency or disaster management cycle as seen in Figure 1.1 covers all four phases of an emergency scenario and details what governments, emergency responders, businesses and everyone involved with emergency management need to deal with.

Figure 1.1. Emergency management cycle.

The emergency management cycle includes four phases, starting with mitigation, preparedness, response and recovery. After the recovery phase, the cycle restarts with mitigation again, building on the actions and lessons learned from the previous cycle.

In emergency management there are two distinct types of disasters, natural and man-made. Natural disasters include everything from floods and droughts to earthquakes to volcanic eruption. Natural disasters can not be controlled in terms of when they will occur or size of the magnitude. Man-made disasters can be categorized as unintentional and intentional disasters, meaning that disaster events on one hand can be accidents such as fires and collisions and on the other, they can be attacks such as terror. Certain disasters can be a combination of the two types, such as epidemics and forest fires.

Every complex system in any given sector (production facilities, residence or office buildings, schools, etc.) is subject to unforeseen events, which given their nature of irregularity in the process, carry negative consequences. Therefore, planning ahead to these events, is a preparedness tool that consists of a quick response time, and organization to perform the right activities in the right order. Such planning, can be focus on 2 approaches, the first, planning in regards of disabling accidents from happening in the first place, for example, valves in pipelines with fail open switches to avoid accumulation of pressure. And the second approach, is to focus on the activities needed to be carried out, in order to minimize the consequences once the event has occurred, for example, emergency response plans for a building on fire. Understandably, for a higher probability of success, both approaches should be applied together, securing the less unfavorable outcome (if any).

In media there is a trend to report disasters and emergencies as bigger, larger and more complex, which would justify the large allocation of resources and focus on emergency management. However, is there a need for more focus on emergency management?

Looking at the risk picture for disasters it seems that there is an increasing trend of natural occurring disasters as seen in Figure 1.2.

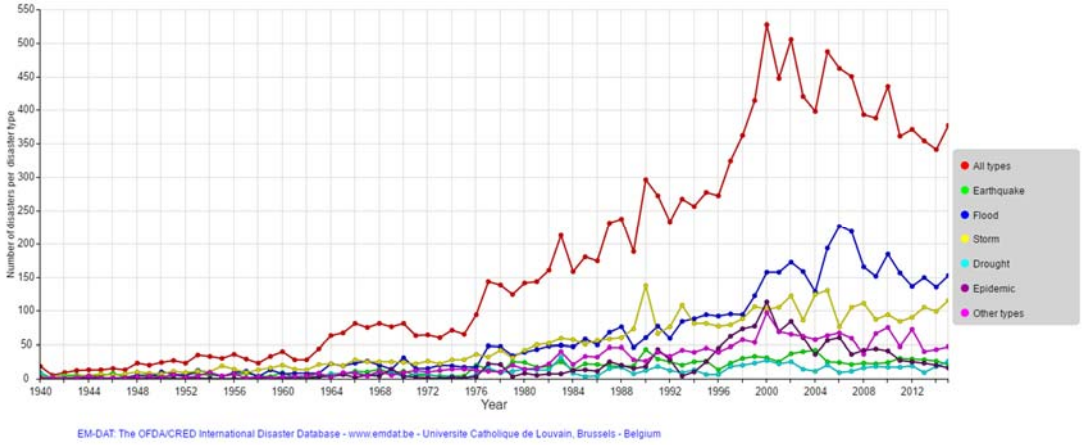

Figure 1.2. Total number of reported natural disasters between 1940 and 2015 [1].

There seems to be a steady increase in total natural disaster reports from 1950 until 2000. A large portion of these can be contributed to better reporting methods, databases, information technology as well as population growth. Scientist and media warning of global warming and the following effects, supports the trend in growing numbers of floods and storms while disasters like earthquakes do not show to increase.

In addition, man-made disasters have seen an increase during the last 50 years as seen in Figure 1.3. Again, a large contributing factor to this is likely to be better reporting methods and more focus on safety culture. The fall disasters around 2007 could likely be contributed to the global financial crisis.

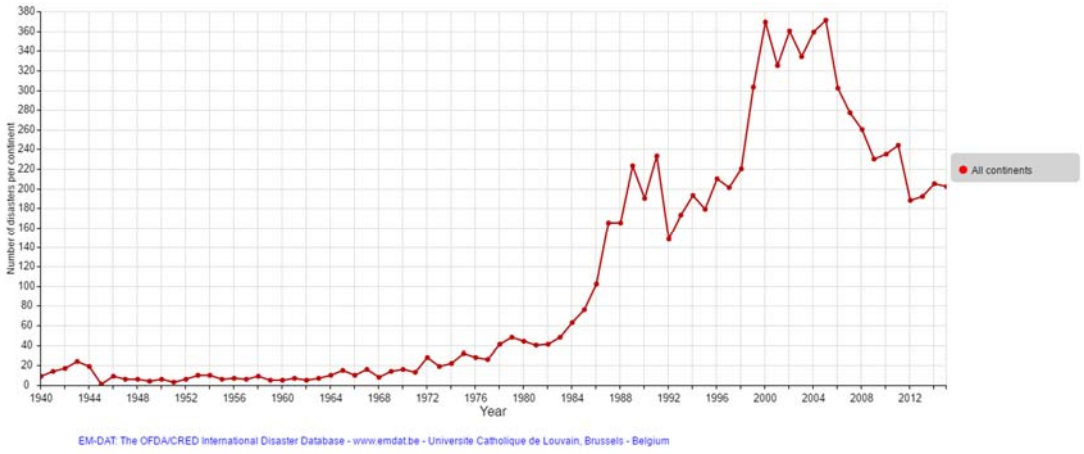

Figure 1.3. Total number of reported technological disasters between 1940 and 2015 [1].

These trends can also be seen economically, were there is a trend of increased losses from natural disasters such as earthquakes, hurricanes and floods. It is estimated that economic and insured losses have increased from $528 billion (1981-1990) to $1,197 billion (1991-2000) and to $1,213 billion over the period 2001-2010 [2].

Another global trend have an effect on emergency management, is the rapid urbanization that is happening. More people now live in urban environments than in rural areas. It is estimated that by 2050 approximately two thirds of the global population will live in urban cities. That kind of population density also means that more people a vulnerable to a disaster if disaster strikes in urban environment [3].

This shows a clear trend globally that a need for emergency and disaster management is needed.

In recent years Denmark has experienced man-made disasters that could potentially have been catastrophic. Most memorably in 2004 the Seest firework factory explosion that showed mass destruction of homes and workplaces, but with minimal casualties

due to a quick response [4]. In 2012 a fire struck at Avedøreværket[1] resulting in a 14 days complex fire operation in order to put out the fire. The Danish Emergency Management Agency alone spent 8,500 man-hours and a craning company supporting the operations reports use of 2,800 machine-hours, showing enormous amounts of racecourses going into emergency scenarios and also affecting infrastructure [5].

The same power plant was this year in 2016 hit by a dust explosion, which did not result in a fire due to active fire prevention systems [6].

Recently a large scale silo fire occurred in Fredericia harbor in the beginning of 2016 showed that there is still a need for quick and extensive response and preparedness [7].

Natural disasters are not common in Denmark, compared to other geographically places on the planet. Although Denmark is a relatively safe country when it comes to natural disasters, incidents are still present throughout history. Most recent is the December hurricane of 1999. On the 3rd of December 1999 Denmark was hit with the worst hurricane in the 20iets century. This storm resulted in 7 casualties and 800 injured civilians, as well as creating damages for 17 billion DKK [8] [9].

Copenhagen has been struck with a lot of flooding in recent years, notably 2011 and 2014, which resulted in closed businesses, damages, infrastructure problems and health problems.

Even in the writing of this report Denmark has been hit with storms and flooding twice during a period of two weeks in December 2016 and January 2017 resulting in a large scale effort to mitigate damages and political talk of distribution of mitigation funds.

In Denmark there are two levels of emergency preparedness - the municipal level and a national level. In June 2014 the Danish government and Local Government Denmark (KL) entered into a budget agreement to reduce the 85 municipal fire and rescue units to maximum 20 units by January 2016 [10]. This is done by creating cross municipal collaborations and combining existing fire and rescue services into so called §60 companies. This constellation enables municipalities to enter into a collaboration and create a “special municipality” that are an independent legal entity. This company can be allowed to take over certain competences that the municipalities transfers to the collaboration [11] [12].

The first emergency response unit was established in January 2014 between Lolland and Guldborgsund municipalities. This structural change has since been implemented

[1] Power station in Avedøre, Denmark.

nationally and in 2015 nineteen first mover municipalities created four new emergency response units: Sydvestjysk Brandvæsen (SVJB), Nordsjællands Brandvæsen (NSBV), Midt-og Sydsjællands Brand & Redning (MSBR) and Østsjællands Beredskab (OESB).

By 11th April 2016 a total of 20 units has been created. However, Bornholm, Tårnby, Slagelse, Sønderborg and Helsingør municipalities have not entered into a collaboration [13].

As said before, complex systems exist everywhere, and they can range in size and functionality. An interesting system to analyze is the city of Esbjerg, given all the different variables that come into play, such as population density, ethnicity mixture, age ranges, production building facilities, and so on.

Being prepared for incidents citywide, is not only for the mere safety of the population, but in some cases such as this, it is demanded by law. In this order of ideas, countries have different setups of systems to attend emergencies, from local authority interaction to greater emergencies including the national guard, and even aid from other countries. As said before, many of these emergency preparedness systems is demanded by law, such in the case for private companies, and/or guidelines established by the local/state government. In the case of Denmark, there is a well established structure leaded by the Danish Ministry of Defense.

The emergency response unit of SVJB is a collaboration of Esbjerg, Varde and Fanø municipalities covering an area of approximately 2,000 km² and 169,000 inhabitants [13]. With this new structure and tasks it is relevant to ask the following initiating question,

How important is emergency management in municipal level?

In order to answer this question a study of the current organization, legislation, planning framework, emergency scenarios and risks, will enable an analysis and further investigation of the emergency management setup of for Esbjerg municipality and SVJB.

1.1 Problem description

With the merger of fire and emergency units there is a new situation and organization for SVJB and here it is important to understand what situation SVJB is facing.

Esbjerg is the fifth largest city in Denmark and is home to the largest harbor in Denmark.

The harbor wharf is stretching over 12 km and the biggest industry of Esbjerg, housing more than 200 companies covering wind energy, oil and gas, RoRo[2] and bulk handling on an area of 2.6 million m^2. In 2015 the harbor had over 6,000 berthing's [14] [15] [16]. In 2015 the harbor handled 4,227,000 tons of goods distributed as seen in Table 1.1.

Categories	Tons [1000]
Trailer / container goods	1.929
General cargo	582
Liquid fuels	615
Stone / sand / pebbles	651
Fossil bulk	375
Solid bulk	75

Table 1.1. Turnover of goods [17].

Esbjerg harbor is a large distribution center for critical parts to the offshore wind industry and oil and gas as well as a hub for car distribution handling more than 58,000 new cars in 2015 [18].

In primo 2015 Esbjerg had a population of 115,446 people. Thereof 8,701 was immigrants [19]. Esbjerg is a university town and has 5 universities with approximately 6,500 students whereof a large portion are international students [20]. There are 32 schools in Esbjerg municipality with approximately 13,500 school children [21]. The age distribution of Esbjerg municipality can be seen in Table 1.2.

Age distribution [years]	No. of people	%
0 - 5	3,647	6.4
6 - 17	8,001	14
18 - 24	5,372	9.7
25 - 64	29,033	51.2
65 - 79	8,721	14.6
80+	2,869	4.1

Table 1.2. Age distribution of Esbjerg municipality 1.1. 2015 [22].

Fanø municipality inhabits 3,302 persons in primo 2016 [23].

Varde municipality had a population of 50,289 persons in primo 2016 with approximately 13,800 living in Varde city [24].

[2] Roll-on/roll-of. Ship and harbor designed to handle wheeled cargo, such as trucks and railroad cars.

From an emergency management point of view, it is interesting to know the demographics of populations for evacuation, risk communication and preparedness purposes.

The Esbjerg, Varde and Fanø municipalities is home to a lot of nature areas and cultural landmarks. Large areas of the The UNESCO Wadden Sea National Park is located in the areas of Esbjerg, Varde and Fanø. Nature resorts like this is are highly complex ecosystems and are vulnerable to environmental disasters.

Esbjerg Airport is located just outside of Esbjerg and operational all year round. Providing services for offshore companies transporting workers offshore by helicopter, as well as daily flight routs to Aberdeen and Stavanger. In 2014 the airport had 15,801 takeoffs and landings adding up to a total of 121,853 passengers [25].

There are 8 Seveso[3] companies in Esbjerg municipal, located in Esbjerg city and Esbjerg harbor. The SEVESO directive categories companies into two different hazard ratings, column 2 and column 3 companies, depending on how much storage of dangerous goods and chemical storage they have. 3 of the 8 companies in Esbjerg are column-3 companies, which means increased reporting, rules and cooperation with local fire department [25].

Legislation

Previously mentioned, in Denmark the emergency management is controlled by the Danish Ministry of Defense, who put in effect the legislation of the Emergency Management Act. The act covers several guidelines regarding authorities in charge of accidents, decision making rank and process, communication, planning, and so on, whether to mitigate or minimize risk on people, property and/or the environment.

The main authority corp under the Ministry of Defense is the National Fire and Rescue Service, and the Ministry have the power to enter into communication with other organization or individuals in order to coordinate the assistance with the Fire and Rescue Service. Regarding municipalities (e.g Esbjerg), the task of emergency management relies on The Municipal Fire and Rescue Service, whom in time belongs under the Municipal Council.

Current plans

The municipality of Esbjerg, Varde and Fanø created a common emergency commission in 2015. Along with this change, the local fire and rescue services was fused together, creating Sydvestjysk Brandvæsen (SVJB) as a joint fire and rescue

[3] European Union directive on control of dangerous goods and chemical storage.

service between Esbjerg, Varde and Fanø municipalities. There is a plan hierarchy for emergency management plans as can be seen in Figure 1.4.

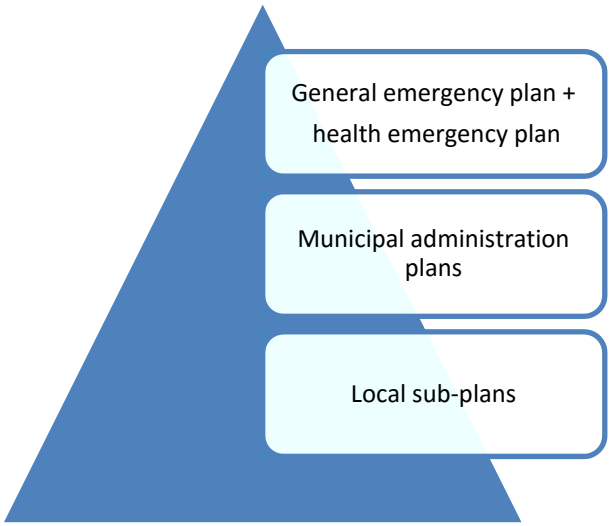

Figure 1.4. Emergency management plan hierarchy in Esbjerg, Varde and Fanø municipalities.

At the top it the General Emergency Plan for Esbjerg, Varde and Fanø municipalities, together with the Health Emergency Plan for Esbjerg SVJB has the responsibility of the general Emergency Plan for Esbjerg, Varde and Fanø.

In the middle layer are municipal administration plans for each municipality. Each sub-administration has the responsibility to create a plan for the administration. The responsibility of the plan falls upon the daily work environment manager.

The bottom level plans are local sub-plans. These local administrations develop plans on a "if necessary" basis. Local administrations can be schools, nursing homes, water supply. Needs to be based on the municipal administration plans that the local administration belongs to.

The emergency plan setup for Esbjerg municipality tries to cover multiple levels of the decision process in an emergency situation. With a plan hierarchy it is very important to have a clear and structured organization as well as communication lines.

Organization

A well organization structure with defined roles, can ensure the best response actions under an emergency scenario. The organization is responsible for the decision making process through the established teams. It is imperative for a successful organization structure, to not only have its personnel in line with response actions, but also, to have well established communication channels, so the information can be properly delivered amongst themselves, and the general public.

1.2 Problem analysis

Denmark is a relatively safe country to live and operate in, both historically and present. According to the World Peace Index Denmark is the 2nd safest country in the world when looking at socio-economic factors [26]. This is supported by the World Risk Report 2016 by the UN where Denmark ranks 149 out of 171 based on natural disasters [27]. However this is not synonymous with a disaster free society and if there is no focus on emergency and disaster management, Denmark might fall for the turkey fallacy.

If there are lapses or gaps in an emergency setup for any kind of system, technical or man-made, there are higher probabilities of loss of life, businesses and a longer recovery phase returning to normal. This can become a problem for all stakeholders, citizens, government, NGO's, civil service, private sector companies, fire and rescue services, first responders, legislators as well as the international community.

In case of SVJB the most affected would be Esbjerg, Varde and Fanø municipalities. However neighbor municipalities can be affected as well in larger disasters where SVJB responds to a crisis situation, and need additional support from neighbor emergency units.

In case of disasters with a longer time frame or demanding a lot of manpower or disasters that might demand special equipment the municipalities can receive assistance from DEMA emergency centers [28]. For a crisis that depletes natural resources, requires technical support or monitoring services, the European Emergency Response Coordination Centre (ERCC) can step in and provide aid.

Emergency scenarios

The DEMA drafted in 2013 a national risk picture for Denmark, listing the ten most prevalent natural and man-made risks from a Danish perspective.

Emergency scenarios can range in different aspects, such as magnitude, manmade or natural disaster, and preparedness levels, amidst others. Such aspects, determine the probability of success -success being defined as the least worse outcome obtained- in the chain of reaction activities. Some of the possible scenarios present in the city of Esbjerg are as follows,

Terrorist attack

Since 9/11, terror attacks have caused more and more fear in people. Legislations and policies have become stronger, and the world changed forever. It is not unusual to hear on the news about terror attacks in the US and Europe. Even though a terror attack in Esbjerg is unlikely probable, a response plan should be available.

Flooding

This event is more likely to happen, given that Esbjerg is a coastal city, and has an elevation of 50 meters above sea level. As a matter of fact, there have studies that claim a rise on the sea level due to the increment of temperature, thus the melting of land-based ice (ice sheets, glaciers).

Fire

Fire accidents can happen in all types of buildings, from schools and museums, to production facilities; this will indicate the magnitude of the event. A fire produced in a toxic waste facility, could create toxic fumes that can affect residents nearby. Since fires have a fair probability of occurrence, there are fire departments, with personnel well trained to respond this event. It is also worth to note, a case that would involve and high scale fire in the city; it has happened before in the neighbor city Ribe.

Extreme weather

Even though weather monitoring is available, conditions can change drastically and catch population by surprise. Extreme weather conditions, such like, lightning storms, blizzards or even heat waves, are serious elements to be prepared for. Also, it can develop other incidents (car accidents, fires, and so on), for this reason it planning for these events is a must.

Virus outbreak

Nowadays, human interaction amongst different nationalities happen everyday, all the time, for example flying passengers with multiple destinations. Thus, it is easier for virus transportation and faster to spread, as seen in the past, with virus like Avian Influenza, Ebola, and recently the Zika virus. Virus contingency through health and safety planning can be achieved.

It is worth noticing that all these scenarios have different probabilities of occurrence (some higher than others), nonetheless, the best outcome can be achieved with planning ahead accidents, reducing time, and gaining effectiveness.

DEMA mapped these scenarios as seen in Figure 1.5.

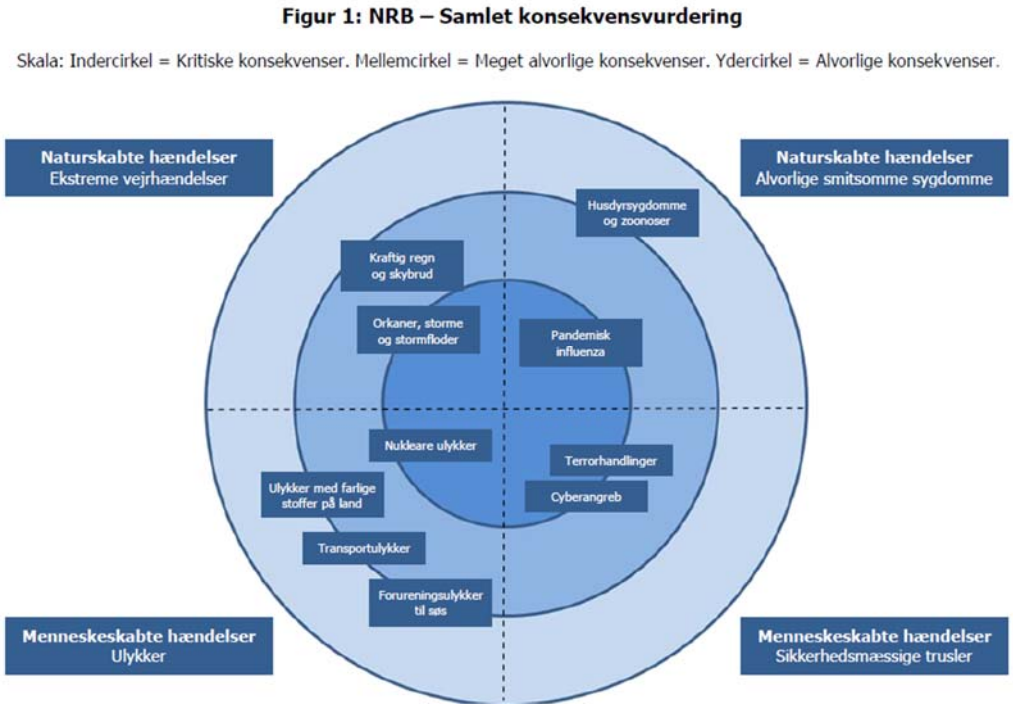

Figure 1.5. Overall impact assessment [29].

In order to create an effective emergency response based on these emergency scenarios, detailed planning is needed along with practice and exercises. Plan rehearsal and exercises are time consuming and costly, the organization must invest significant resources into planning and evaluating an emergency exercise as well as unavoidable downtime during the running trial. Therefore, the response phase is often neglected in a preparedness perspective. By using computer simulations that can mimic the emergency scenarios and provide detailed data on response, communication and plan validation, the response phase can be better planned. Simulations are able to provide facts instead of assumptions made in a normal tabletop exercise setting. A simulation is flexible and adaptable and can easy simulate multiple different scenarios. This enables the organization to save resources.

Summary

With the risks that follows natural and man-made disasters there is a need for an increased focus on emergency management. Following the crisis management cycle there are multiple steps that need focus. Analyzing risks that needs mitigation and

preparedness planning will be the first two steps that needs to be covered. The emergency management plans will be developed and approved for use in emergencies. Response and recovery phases however will first be tested when an emergency happens. This can prove detrimental to the emergency response if there are gaps in the system. Therefore it is important to include in the preparedness phase validation of the plans via exercise or simulations. Exercises or simulations will be able to provide a platform where the response and recovery can be tested as a simulated event. Eliminating gaps between the preparedness and response phases.

1.3 Problem formulation

As seen previously, there are many emergency scenarios where the city of Esbjerg can be vulnerable to, where negative consequences can occur, such as damage to the city's infrastructure, population, and the environment to mention some. Thus, preparedness through emergency reaction plans must be able to perform at its best. Having this in mind, it is fair to question the efficiency of the current preparedness stage of the city, including different factors, for instance communication channels and systems, population information, emergency plan configuration, organization structure, and so on. Resulting this, in the main question posed as follows,

Is the emergency management setup for Esbjerg municipality and SVJB appropriate?

As said before, the Esbjerg municipality has emergency reaction plans already established, and getting familiar with them is the first step for solving the main question, as well as the main actors, organizational wise. An important aspect to consider, is to go over the Danish Legislation regarding emergency planning, and determine if such plans follow the standards and guidelines stablished by the Danish Government. To allow a simulation to take place, it is necessary to setup a hypothetical (although plausible) emergency scenario that would affect the city. To complete the investigation, such plans and emergency setup should be put to the test with a simulation software, in order to assess any potential gaps with the emergency management response. This analysis brings to the table several sub-questions, such as:

1. How are the current organization and plans setup to deal with emergencies?
2. Is it possible to use simulation software to aid an emergency management exercise?
3. Can an exercise reveal future focus for emergency management?

The first question deals with an overview and identification of the main elements within an emergency plan, such as the organization, the actors and their roles. The second question, relies in creating an emergency case scenario, which would serve as base for testing such emergency plan. Question three is the actual test, running a

simulation software to determine the efficiency of the emergency management, and assess any potential gaps. These questions in combination, cover a wide range of techniques and analysis tools learned throughout the MSc. Risk and Safety program.

1.4 Problem delimitation

The scope of the thesis does not cover the municipalities of Fanø and Varde, even though they are tied to the same organizational configuration, for the main reason that whatever improvements can come up, are transferable to these other municipalities. Moreover, the focus on the legislation will be restricted to the emergency management planning structure, given the extensiveness of it. Also, when looking into the emergency scenario setup, although several scenarios are explained from both types (natural and man-made), the approach is dedicated solely to natural disasters.

1.5 Outline

This investigation covers several elements learned throughout the entire risk and safety program such as, risk assessment, decision making, emergency management, stakeholders and simulation amongst others. It is divided in 4 chapters, concerning the main elements to be discussed and analyzed.

Chapter 2 will cover the description of the emergency management plans, and the organization structure under such are made. Moreover, it will have a brief view on the base legislation acts and a comparison of these guidelines and current plans will be stablished.

Chapter 3 deals into the emergency manage setup. A natural disaster will hypothetically happen in the city of Esbjerg, where it will be stablished several factors, such as magnitude, people and places affected by it, and obstacles for the municipality emergency team to overcome.

Chapter 4 with the use of a simulation software, the previously emergency setup will be added, alongside with the current emergency management plans, in order to analyze their effectiveness. Moreover, a live simulation should be stablished to measure the preparedness status on the emergency management department.

Chapter 5 analyzes the emergency management system with a non-trivial socio-technical analysis method called The Functional Resonance Analysis Method (FRAM).

Chapter 6 concludes on the previous chapters and compare the findings with the questions defined in the problem formulation.

2

Emergency management framework

2.1 Legislation

Standardization of rules is a must in any type of society or system, no matter the size, in order to follow the same guidelines. Such rules, help to keep order in the working environment, and most importantly, to avoid misunderstanding that could lead to problems or accidents.

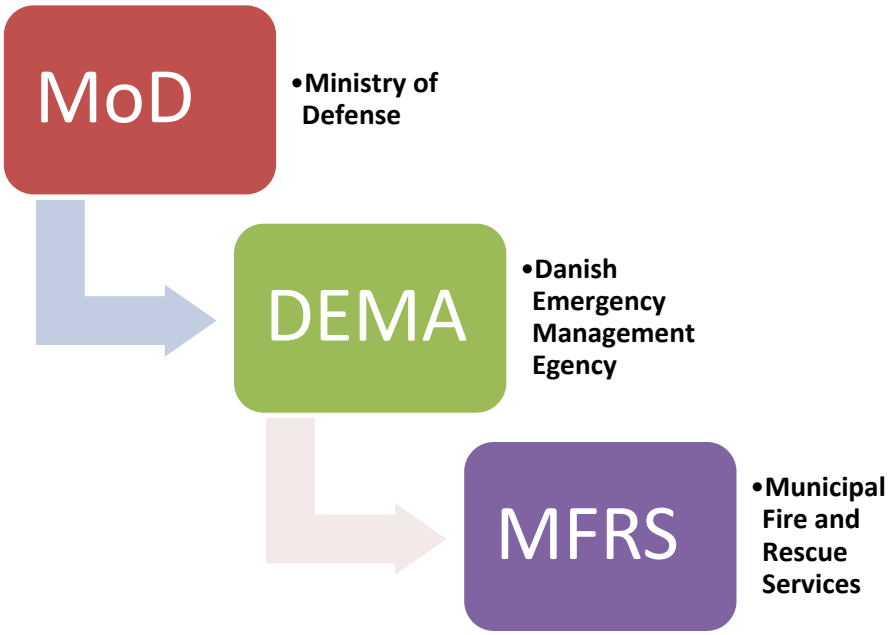

Figure 2.1. Organization chain of command

Legislation in Denmark, regarding emergency management is guided by the Danish Emergency Act (Consolidation Act no. 660), lastly updated in December 17th 2014. The main organism in the top of the chain of command is the Ministry of Defense as seen in Figure 2.1, which lays and imposes the rules, guidelines, and disciplinary actions among its duties. Under the Ministry of Defense, and the organism appointed to keep track on the legislation, is the Danish Emergency Management Agency (DEMA), which is responsible of the Danish National Fire and Rescue Service,

consisting of six centers nationwide. DEMA's functions include among others technical prevention, administration of rules and regulations. Manage, develop and implement a wide range of emergency training courses. Also, to supervise and provide advice to local rescue and fire services, and coordinate preparedness planning. And lastly, under DEMA comes the Municipal Fire and Rescue Services, which operates on a more local level for the different municipalities [30].

This last step in the organization chain, is the case of study for this investigation. Looking through the legislation, there are no specific steps to follow for any given emergency scenario, but it explains the different actors and their responsibilities. In this order of ideas, the responsibility for detailed emergency plans relies on the fire department of the Esbjerg municipality, alongside with Fanø and Varde municipalities; and the city's crisis unit.

2.2 Organization

The Danish Fire and Rescue Services is divided into the national fire and rescue service and the municipal fire and rescue service. On a national level it is the DEMA as described earlier.

Chapter 3 of the Emergency Management Act covers the responsibility of municipal council level. The first responsibility of the municipality council is to create an emergency management commission.

The organization of the emergency management commission will consist of an uneven number of members, including the mayors of the participating municipalities and the police commissioner. A representative for the volunteers also needs to be appointed to observe if there is no representatives for volunteers in the emergency management commission [31].

Emergency management commission

The task of the emergency management commission is to work together with the fire and rescue services on fire and emergency related tasks. These tasks are construction, installation and facility related tasks, such as acquisition of material, fixtures and equipment along with construction plans and construction work.

The current emergency management commission of Esbjerg, Fanø and Varde consists of 7 members and 3 observers as seen in Table 2.1. The current commission is constituted from primo 2015 until ultimo 2017.

Name	Municipality	Title
Johnny Søtrup	Esbjerg Municipal	Committee chairman Mayor
Erik Buhl	Varde Municipal	Mayor
Erik Nørreby	Fanø Municipal	Mayor
Jørgen Ahlquist	Esbjerg Municipal	City council member
Kjeld Anker Espersen	Varde Municipal	2nd vice mayor
Kristine Kaas Krog	Fanø Municipal	City council member
N/A	A representative for Syd- og Sønderjyllands Police director (Jørgen Martin Meyer)	N/A
Bent Kristensen	Esbjerg	Observer for volunteers
Christian Mortensen	Fanø	Observer for volunteers
Kim Aasted	Varde	Observer for volunteers

Table 2.1. Emergency management commission members [32].

SVJB

SVJB is the joint fire and rescue services for Esbjerg, Varde and Fanø municipalities. The administration of SVJB is located in Esbjerg city. There are a total of 11 fire stations throughout the coverage area of SVJB ensuring satisfying response time for all citizens.

SVJB are tasked with providing limiting and mitigating action in the following operations [25].

- Fire or imminent danger of fire
- Alarms from active fire prevention systems
- Explosion
- Building collapse accidents
- Train accidents
- Aircraft accidents on land (assistance coastal areas)
- Ship accidents at berth
- Entrapment accidents in road accidents, machinery, etc.
- Height and depth rescue
- Natural disasters
- Distressed on lakes, marshes, creeks and harbors (assistance coastal areas)
- Immediate accidents involving dangerous substances on land, in lakes, in rivers and harbors
- Other rescue, where there are acute and imminent danger to humans or animals
- Other mitigation and remedial actions by other acute accidents when the emergency call center requests assistance

- Need for reception, accommodation and meals for evacuees and other distressed

In addition to the above operations list, SVJB can agree to help with certain operational MAY tasks that are under legislative responsibility of other authorities, but are outsourced or entered into joint collaboration in case of logistical limits [25]. These operational MAY tasks can be seen in Table 2.2.

Operational MAY tasks	**Responsible Authority and the Act on reference etc.**	**Remark**
Rescue tasks in coastal areas	SOK[4] / Police	E.g. a municipal raft agreement
Combating pollution in coastal territorial waters	SOK - Law on the Protection of the Marine Environment	
Diving service	SOK / Police	
Elevator downtime	Danish WEA[5] instructions	
Emergency drinking water supply	Concerned waterworks	Rescue services can to a certain degree contribute with water tanks and logistics
Emergency power supply	Power supplier / civil emergency / own responsibility	Emergency power generators, etc.
Person search	The Police	Supporting with manpower

Table 2.2. Operational MAY tasks for SVJB [25].

The daily management of SVJB is in the role of head of fire and rescue services, currently Jens Mølgaard. In case of absence of the head of fire and rescue, a deputy position will take over the daily management. Operations are controlled by chief of operations, currently Niels Strandvad Thomsen.

The rest of the organization consists of 15 full time employees taking care of fire related building permits, vehicle maintenance, administration, preparedness planning among other administrative tasks.

The operation region of SVJB has been divided into 3 areas, each with its own incident commander, leading the operation effort in an incident.

A major part of the emergency response by SVJB is supported by the volunteer emergency services. Approximately 140 volunteers are connected to SVJB distributed on all fire stations in the municipals. These volunteers are a supplement to the fire and rescue response and will be activated in tasks like the following [25].

[4] SOK (Søvernets Operative Kommando). Part of the Defense Command Denmark
[5] Working Environment Agency

- Flood Preparedness
- Meals for emergency responders in larger operations
- Meals and accommodation in distress
- Pump tasks related to weather conditions
- Light and oxygen at site of injury
- Communication
- Supplementing the daily preparedness as a replacement for long-term operations
- Bracing tasks
- Cover and storm protection
- Samaritan guards at major events
- Snow preparedness and response
- Tree removal in connection with the storm
- Water supply for animals, etc. in case of power failure
- Emergency power supply
- Assist in major accidents, manpower for stretcher transport, blankets, tools and equipment, etc.

Esbjerg Municipal

Esbjerg Municipal is organized and executive board directly below the mayor. This organ takes care of the different administrations that are responsible for the municipal services. There are five different administrations

- Joint administration
- Children and Culture
- Engineering and Environment
- Health and Care
- Citizen and Job Market

This organization can be seen in Figure 2.2.

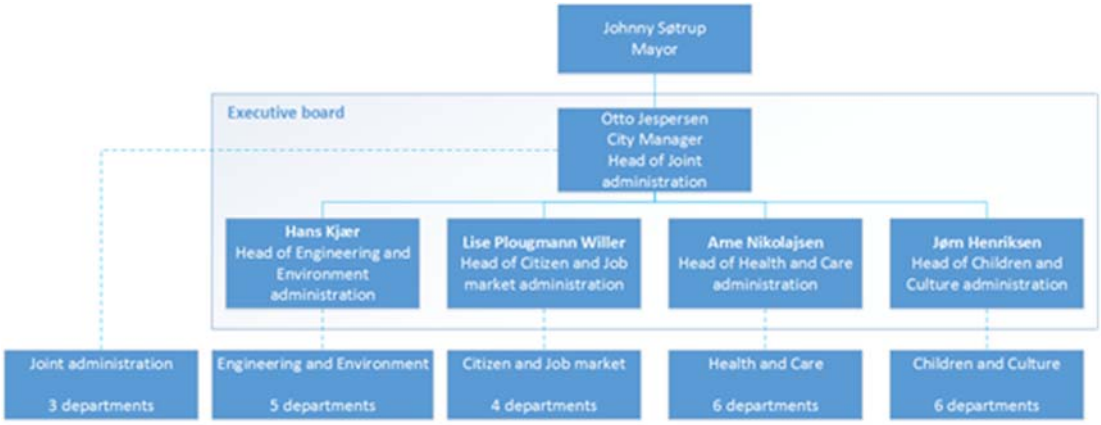

Figure 2.2. Esbjerg Municipal executive board and administration organization.

2.3 Emergency management plans

Risk based dimensioning of SVJB

It is the responsibility of SVJB to detail an analysis of the administrative, operational and hazard risks that SVJB are facing. This document is reviewed minimum once every municipal election period.

It provides information of organization, administration, logistics, locations, equipment, collaborations and operation tasks. Furthermore, it also provides statistical data, risk analysis and exercise scenarios.

General emergency management plan for Esbjerg, Varde and Fanø

SVJB is responsible for developing and maintaining the general emergency management plan for the three municipals. This plan is the result of the creation of the article 60 company that SVJB is. The plan ensures the effective service and handling of tasks in extraordinary situations that demands extra resources.

The plan are updated minimum once every election period for the city councils and at least once every election period the plan must be revised and approved by the three city councils. Along with this, it falls upon the head of fire and rescue SVJB to perform one or more exercises where the municipals tests and train the general emergency plan.

The plan list examples of typical situations where the general emergency plan could be activated [33].

- Extreme weather conditions (climate events)
- Major accidents (trains or aircraft accidents, toxic spills, major pollutants, etc.)

- Longer operational disruptions crash of IT, phones, electricity, water, sewer- or heat supply.
- Safety threats and disturbances
- Epidemics
- Major events affecting the ability of municipalities to maintain the normal level of service to citizens
- Where the local emergency staff is reduced
- At the request of the DEMA or AMK (emergency medical coordination center)

In case of any of these scenarios, the head of fire and rescue SVJB will evaluate and asses if it is necessary to activate or warn the crisis unit. It is the responsibility of the head of fire and rescue to activate the crisis unit. All members can be activated if deemed necessary, however it is also possible to gather a crisis unit consisting of members only related to a certain municipal or affected area. The current crisis unit is organized as seen in Figure 2.3.

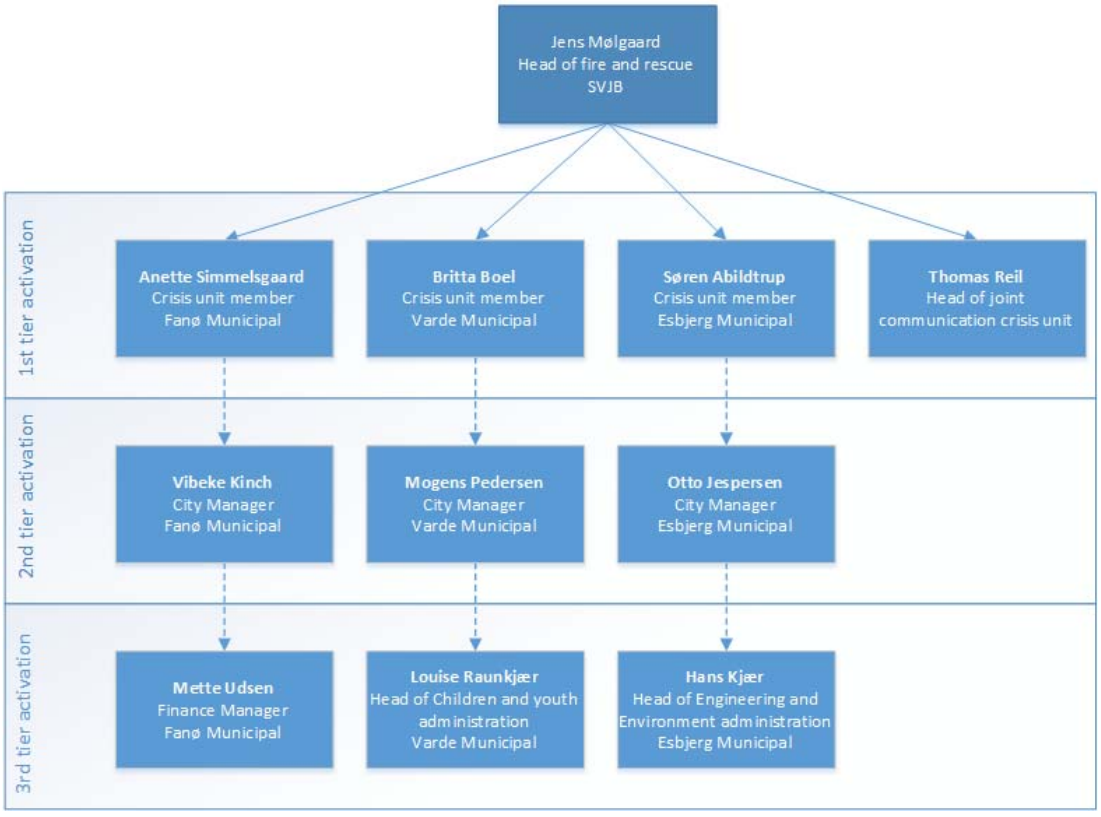

Figure 2.3. Crisis unit for Esbjerg Municipal

The tier 1 level can consist of 3 crisis unit members and 1 joint crisis communication member as seen in Figure 2.3. In case an individual member is unreachable, the 2nd tier substitutes will need to take over the crisis unit member role. There are 2 levels of substitution activation for each crisis unit member.

There is no substitute for the head of joint crisis communication; however, this role will be easier to fill out with communication consultants from different administrations of the municipals.

Activation of the crisis unit is based on the current or eminent emergency level. SVJB operates with 3 distinct levels [33].

Level 1 – Information Contingency

> *"Information Contingency is used for events or upcoming events that may have implications for daily life, operations and infrastructure in the municipality. However, it is estimated that at executive level in the municipalities does not need to be taken significant initiatives for continued municipal operations.*
>
> *The briefing is from SVJB to the crisis unit and the head of communications in Esbjerg Municipal via sms/phone/mail.*
>
> *Crisis unit members assess the need for additional information in their own municipality."*

Level 2 – Staff Contingency

> *„Staff Contingency is used where it is not excluded that the events or warning of events within a short time frame (hours) can lead to consequences for continued municipal operations, changed infrastructure and where it is assessed that municipalities at board level must make decisions/measures directly affecting one or more administrations.*
>
> *The activation of the crisis unit will happen as either a warning of meeting or call for meeting. This will take place from SVJB by phone.*
>
> *Crisis unit members assess during Staff Contingency if additional resources/information to key personnel in their own municipality is necessary. After consideration of the crisis unit members, other participants may be electronically connected via e.g. Skype or FaceTime."*

Level 3 – Operational Contingency

> *"Operational Contingency is used when an event has happened or is imminent, and where there is a need for the municipal management to handle all crisis management relevant tasks at once and for a longer period.*
>
> *Warning of immediate emergency meeting in the crisis unit will happen by phone from SVJB."*

When the crisis unit is activated and called to meet, the members will assemble in SVJB headquarters at Vibevej 18, 6705 Esbjerg Ø. Here an EOC (emergency operation center) is ready for the crisis unit. The EOC will most likely already be in action with fire and rescue operations. The EOC is compromised of two rooms, an emergency or staff operation room or and a conference and decision room as seen in Figure 2.4. In case of longer emergency operations a dedicated rest and relaxation room will have to be prepared separately.

Figure 2.4. Emergency operation room and conference room [33].

The staff operation room is shared between the crisis unit and the operational staff from SVJB. From this room the crisis unit will be able to follow news feeds and communicate with all involved stakeholders.

The EOC is an essential part of an emergency management process. It is the center hub for most decisions and a lot of information is channeled through. Looking at crisis resource management, the environment has an important supporting role to play in the performance of complex tasks.

When the crisis unit arrives at the EOC it will be able to access information from a lot of different agencies and parties. Some of the most relevant communication channels can be seen in Figure 2.5. The model tries to show which relations are most likely to exchange a lot of information with a bolder connection points.

A central point of the emergency management process, it is essential to update and create a situational and risk picture to maintain a overview of a constant changing situation. It is the responsibility of the head of fire and rescue SVJB to provide this report whenever the situation is changing or before a staff meeting. An example of such situation and risk picture can be seen in appendix A.

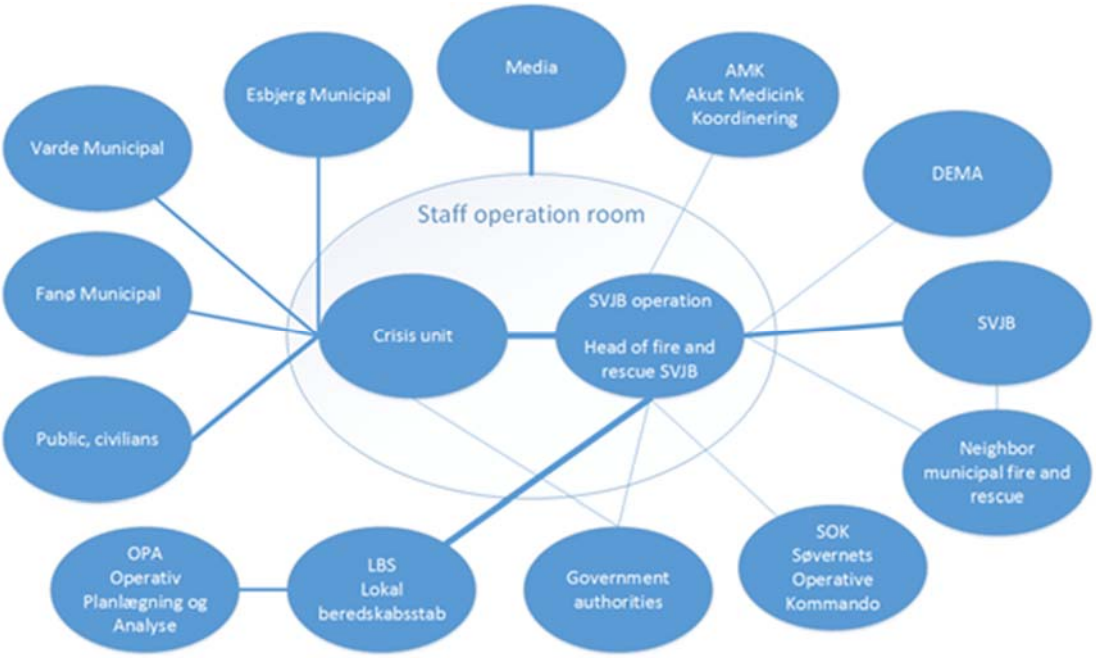

Figure 2.5. Basic overview of communication flow.

Municipal administrations sub-plans

The general emergency plan states that the individual municipal administrations are responsible for developing and maintaining their own emergency management sub-plans to cover the tasks in the different departments as seen previous in Figure 2.2. In line with the general emergency management plan, the administration sub-plans must also be reviewed minimum once every election term.

Municipal administrations in Esbjerg with emergency management sub-plans

- Joint administration
- Children and Culture administration
- Engineering and Environment administration
- Health and Care administration

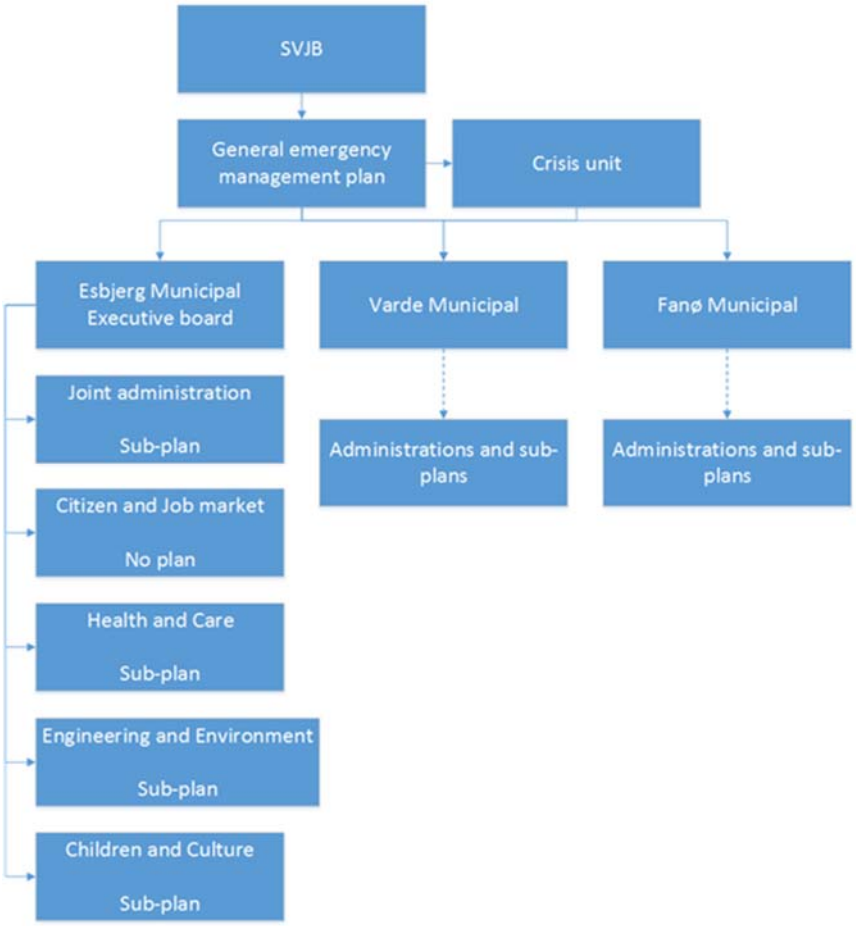

Figure 2.6. Esbjerg Municipal administration organization of emergency management sub-plans.

As seen in Figure 2.6 there are existing sub-plans for 4 administrations. The Citizen and Job Market administration does not have an existing plan.

Varde and Fanø Municipals are also subjected to develop their own plans for each administration. However, this has not been part of the investigation for this report.

Generally the administration sub-plans covers organization and operational tasks as well as detailing which scenarios would activate the plan. Each administration also provides a crisis unit for the department specific tasks.

Planning context

David Alexander, professor of Risk and Disaster Reduction at University College London, argues that the municipal level of emergency planning and response should be the *bedrock* in emergency management. This is due to the response to emergencies are mostly always locally based. First responders with the resources immediately available will be the initial response. The knowledge of arears, cultures and local

conditions are also best known by the local population. [34]. This underlines the importance of proper municipal emergency preparedness planning.

This understanding can be seen in Figure 2.7 where Esbjerg Municipal and SVJB would be in the middle of the model. The different municipal administrations supports the emergency planning with it owns sub-plans customized for the needs by their activities. These plans are still controlled at the municipal level. The municipal plans and emergency response are part of the regional and national emergency plans, which are supporting and guiding the process for the municipal level.

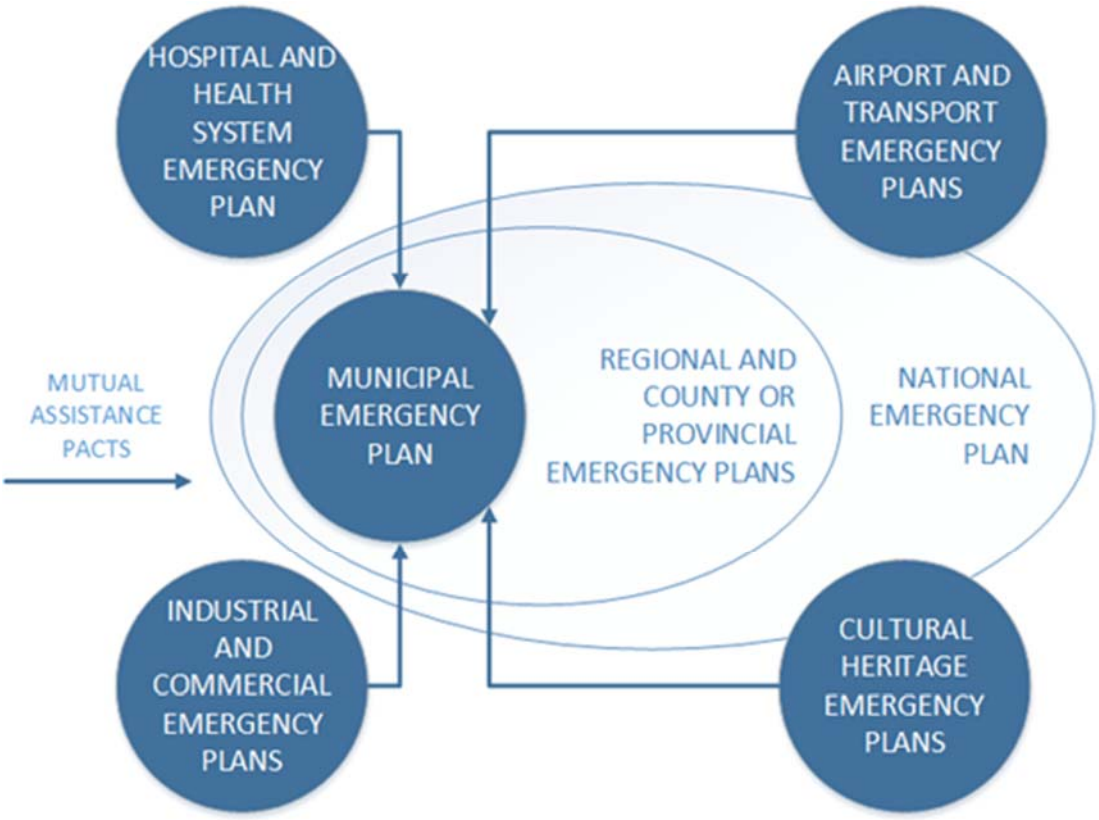

Figure 2.7. The municipality as the "bedrock" level of emergency planning, with connections to other levels and fields on a "nested" assemblage of plans [34].

2.4 Risk communication and emergency warning

In case of major incidents or emergencies authorities in Denmark can inform citizens in different ways. Most frequent is using national media via TV, social media and news websites. It is important to be able to inform and warn populations effectively in case of major emergencies. In Denmark there are implemented

Siren warning system

In major emergency situations siren warnings can be broadcasted in a certain affected area. These siren warnings are commonly known by the public and are tested once every year on the first Wednesday of May at 12 pm. The siren warning covers approximately 80% of the population and the police can cower the remaining population with mobile siren systems [35].

The procedure for a siren warning is to go indoors, lock windows and doors and shut of any ventilation installations. Then follow the news, either on the radio, web or TV. Even though this procedure is commonly known by the general population, it is often seen that citizen do not follow the warning procedures. People are curious by nature and will be interested in going to the emergency site to witness the incident with own eyes or simply ignore the warning signals and go about with their day. It is very important that citizens have a trust in the warning systems and know how to follow the procedures and do it [36].

Mobile warning system

A new national mobile warning systems via app has been introduced in 2016. A free app that citizens can download and get warnings directly to their phones when government agencies put out warnings of major incidents. It works for both Android and Apple systems, the android version currently has 10,000-50,000 downloads. It works with GIS (geographic information system) data and will warn depending on which geographic position the user are in. Users can also predefine areas of interest to receive warnings based on specific locations. Agencies that are included in the warning system are DEMA, DMI (Danish Meteorological Institute), The Danish Road Directorate and the Danish police [37].

Social media

Today social media is a major part of most citizens life's and people are always close to and able to interact with friends, colleagues or strangers via the advancement of social media platforms in case of blogs, social networking, chat rooms, forums, collaboration software and sharing of audio, pictures and videos. This offers civil protection services to effectively communicate with the public in a much more direct way, than by using conventional mass media channels as pictured in Figure 2.8.

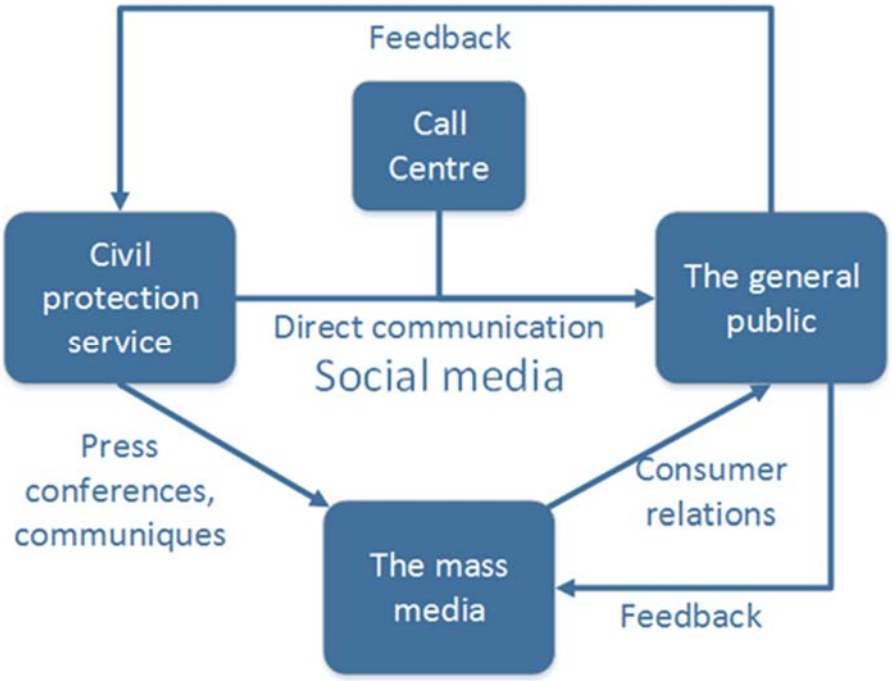

Figure 2.8. Information flow between a civil protection service, the general public and the mass media [34].

Esbjerg municipal uses social media to connect to its citizens. Particularly Facebook @EsbjergK and Twitter @EsbjergKommune. On Facebook Esbjerg Municipal has 10,729 likes which for a large part also means that people follow and for Twitter the municipal has 969 followers [38] [39]. Both accounts are regularly used for informing the public of events, news and warnings. The Twitter account are often re-tweeting posts from the Danish Police twitter account with emergency warnings. This is an effective way to communicate warnings out to the public and in the recent storm during Christmas of 2016 Esbjerg Municipal posted warnings on both Twitter and Facebook as seen in Figure 2.9. These posts shows an active participation from citizens, preparing for the storm and warning friends and family, effectively spreading the message via social media.

Figure 2.9. Twitter post from Esbjerg Municipal [40].

A post on the Esbjerg Municipal Facebook page about the storm warning on December 26th 2016 is an excellent example on how public risk perception can affect peoples severity understanding. The post warns about storm and high waters, encouraging the public to prepare vulnerable houses and properties, as well as removing cars from flood prone arears. The comment responses from civilians shows however that some groups take lightly on storm warnings. There are responses such as, „This light breeze is nothing when you come from Esbjerg", mocking people from Copenhagen due to the fact they categorize it as hurricane as seen in Figure 2.10. This is contributed to the cultural understanding that Esbjerg and the west coast of Denmark is used to harsh weather and a storm warning likely considered business as usual.

Figure 2.10. Facebook post from Esbjerg Municipal [41].

This kind of sense of resilience among the population is often seen and can be problematic in case of major emergencies if the public does not follow warning and guidelines provided in risk communication by authorities.

Crisis communication with citizens is a challenging tasks for every stakeholder in an emergency scenario. Kurt Petersen, professor at the LUCRAM Center at Lunds University in Sweden, points out that it is a commonly recognized view that it is very

difficult, if not impossible to control citizens behavior in a emergency situation. This is backed up by experience from the terror bombings in London in 2005 [42].

It is very hard to control communication flow today by using ordinary mass media. Therefore it is important that civil protection services and municipals take to social media and utilize it to improve the communication quality.

SINE Sikkerhedsnet

Communication channels to the general public is not the only communication systems that emergency services needs to control. The communication between agencies, fire and rescue, police and all other civilian protection services involved, needs to be able to communicate effectively and securely with each other.

Danish civil protection and emergency agencies have implemented and are using a joint communication system called SINE, which stands for Safety Network. SINE was implemented around 2007-2009 and was finally approved for emergency use in 2010. The emergency management act requires that civilian protection services uses SINE to solve emergency management tasks nationally and across agencies.

The Centre of Emergency Communication is tasked with securing the operation and development of the SINE network. It is estimated that more than 45,000 users from professional emergency agencies are connected to the network. SINE is designed and built after the TETRA (TErrestial TRunked Radio) standard which is widely used in the EU and defined by ETSI European Telecommunication Standards Institute. There are 500 antennas covering Denmark with a 99.5% rate, in the 143 largest cities extra strong coverage, resulting in 62% of the Danish land area and 86% of the Danish population will have extra strong coverage [43]. There are built in redundancy in the system that makes sure that an antenna is taken offline in case of interrupting the signal, as well as mobile solutions for coverage security. The power supply is also secured with emergency generators.

The systems works through a simple system where the radio signals go from the distributed antenna network through cables to SINE central. From here the signal is broadcasted to the intended receiver or to an ICCS (Integrated Control and Command System). ICCS is a link between the network signals and functions to a control center. With an ICCS system the functionalities of the SINE network, such as dispatch services, can be accessed at a data terminal with the correct software. This system can be seen in Figure 2.11.

Figure 2.11. SINE network structure [44].

The importance of effective cross communication systems during emergencies are underlined in studies that reveals that especially the interaction between different agencies and authorities are failing under duress. A much more holistic approach is needed in the emergency management process across agencies [42].

3

Simulation software scenario

3.1 Emergency Scenario

As said before, the simulation process was made in conjunction with the Esbjerg municipality, the Fire Department of the city of Esbjerg/Varde, and Aalborg University. With help provided by Jens Mølgaard, several emergency scenarios were made before-hand, having in mind different aspects such as probability of occurrence (for a city such as Esbjerg), and degree of difficulty for the emergency management team since this would be their first time acting as a unit in a medium scale simulation. The scenario is as follows.

From week 47 there is a report of a major storm with low pressure approaching to Denmark. On Monday the 28th it maintains forecast and late in the afternoon, it is expected that a storm with wind gusts of hurricane force will “go ashore" into the western coast of Esbjerg city on November 29th. During the morning of the 29th, the situation in Esbjerg city escalates quickly, being catalog as serious by the police department, and the crisis unit is summoned by 12 o’ clock noon.

The emergency scenarios at the time the crisis unit is assembled are as follows:

1. A train from Østerbro to Esbjerg carrying 80 passengers will be stopped at Bramming station not being able to continue its journey. Management team should come up with a solution in order to deal with the passengers wellbeing and logistics.
2. Eva Sørensen, a nurse driving around the city is stuck with her car on Sjelborgvej 22 due to a fallen tree.
3. A ferry from Fanø is coming to the harbor with 80 passengers.
4. Kvaglund school’s roof is damaged. Actions are to be taken, whether the parents should come pick the kids, call the fire department to take control, or just let them be inside if there is no high chance of injuries.
5. A 60 kw transformer has been damaged, causing a blackout in the area of Sønderris and Grønlandsparken.
6. City buses driving around the city.

7. The janitor at Esbjerg Municipality is calling the leader since he will be asked about the need to go home for the day for workers, and how they must deal with children pick up.
8. Cederlunden 21 is on fire.
9. Plejecenter Hedelund (nursing home) asks how to deal regarding tonight's meal service delivery.
10. Dike Darum is overflowed.

All these emergency scenarios are able to be added to the software EDMSIM, some of them with minor limitations in a sense of graphic representation, nonetheless visible with some explanation ahead.

3.2 EDMSIM

Emergency Disaster and Management Simulation Software (EDMSIM), is a software created by the company C4i located in Canada, whose main aim is to assess potential emergency scenarios, and how to deal with them; making possible the assessment of response time, actions taken consequences and the result of such. Given the versatility of the software, emergency simulations can range from a simple house fire, to a nuclear disaster. An important aspect, and the main reason for which this software was chosen as a tool for the current research, is that the emergency simulations focuses on a city wide scale, suitable for the thesis emphases, and work with the Esbjerg Municipality.

Currently, there are other industries using EDMSIM such as the US Northern Command, US Army, US National Guard, Centers for Disease Control and NATO for training exercises.

3.3 EDMSIM User Interface

The software is easy to use once all commands have been learned. It takes some time, but understanding the software capabilities makes creating emergency situations in a fast pace, given the user friendly interface. Some emergency scenarios can be found preset already, for situations like nuclear disaster, biological hazard, and earthquake among others. Given the fact, that the emergency scenarios in this investigation are varied, the generic module had to be used. Within this module, it is possible to work your way around into creating multiple scenarios.

The software consist primary in 3 main windows, the general map, the emergency scenario module, and the unit organization.

General map

In this window it is possible the positioning and location of the units in the world map. As seen on Figure 3.1, it has an interface similar to google maps, continents, countries, even streets, are able to be located. This feature is helpful in many ways, on one hand, it makes the placement of units as accurate as possible for the simulation in relation to the reality. On another hand, visual support is always a good way to interact and explain to management positions, it is not as easy to digest as just showing some probabilistic data and numbers.

Also in this window, there are 4 tabs for file data management, such as:

- File, for settings.
- Report, which enables the creation of reports after a simulation is done. Some of these reports include among several,
    - Personnel Status
    - Casualties
    - Search and rescue
    - Hospital Report.
- Window, to open up main and secondary windows.
- Help, system's information and system's troubleshooting.
- Map layers, advance visualization of the map, satellite view.
- Drawing overlays, adherence of shapes on the for the purpose of better explanations.
- Bookmarks, capability to save and quick access to precise views of locations in the map. For example, a zoom into a building in the Esbjerg city.

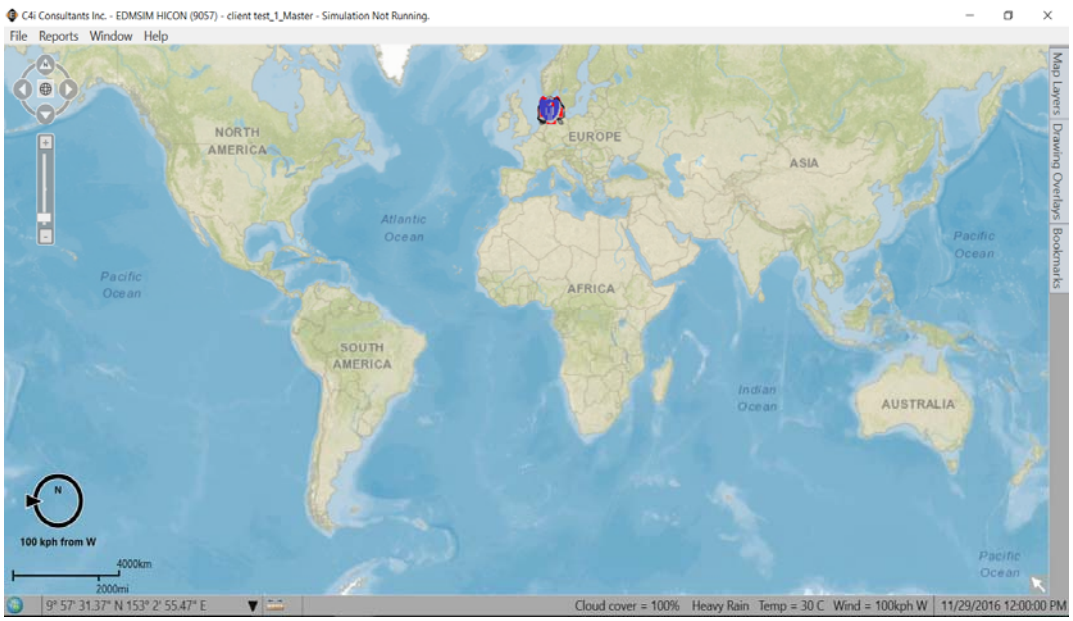

Figure 3.1. General map window.

On the bottom section of this window, some information is displayed, coordinates of the position of the mouse regarding the map, and weather conditions: cloud coverage, rain setup, temperature, wind speed, time and date.

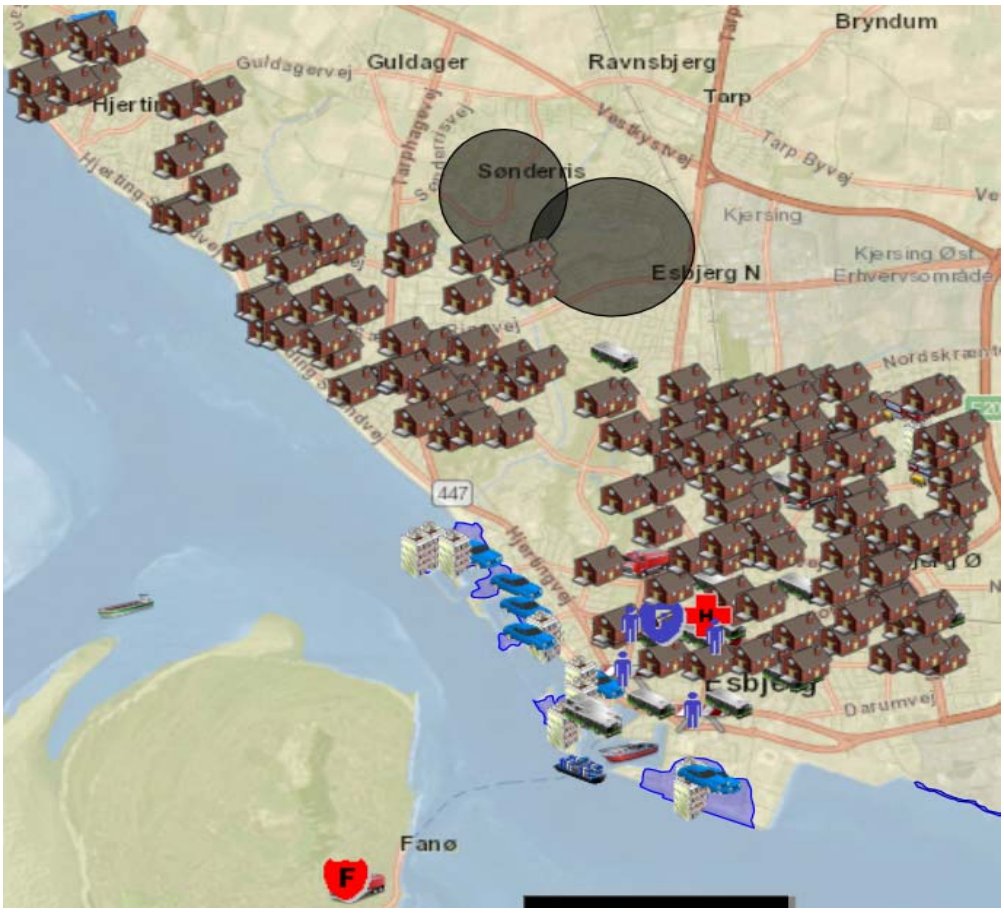

Figure 3.2. Esbjerg city on simulation map window.

As discussed in the scenario setup at the beginning of the current chapter, the emergency takes place in the city of Esbjerg, Denmark (Figure 3.1). Consequently, all units are place around the city, according to the indications made in the setup, as seen on Figure 3.2.

Emergency Scenario Module

This window allows to create the different emergency scenarios that will be placed on the map. As said before, there are several preset emergency scenarios as seen in Figure 3.3. This preset scenarios, are customizable, and they come with general default

settings, mostly the quantity and degree of damage of units, and the magnitud of the event. The main 4 tabs for the control of this window are:

- File, saving commands, language (enlgish, spanish, french and portuguese), and units of measure settings (metric, imperial).
- Emergencies, preset emergency scenarios.
- Control, to control the start, pause on stop of the simulation, also manipulates the time speed.
- Setup, general settings not related to the scenario itself.

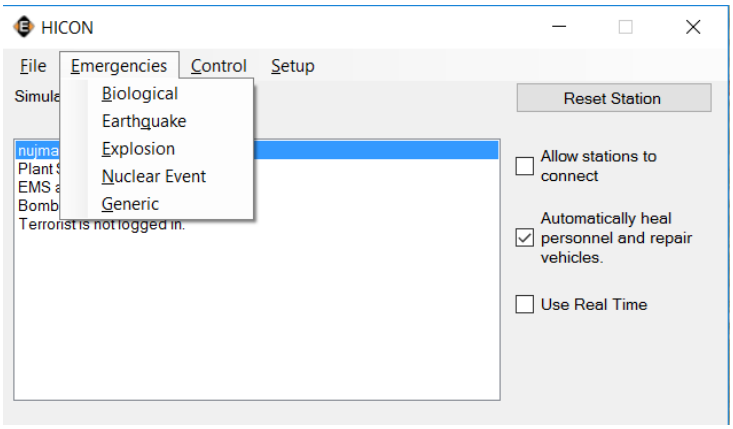

Figure 3.3. Emergency Scenario module window

As said before, the emergency scenarios imagined for the simulation are generic types, hence the use of this option. Following, is a description of the situations setup in the software's module,

General Situation

There is a major flooding at the harbor and it is represented with 4 continuous events, marked with blue color, as seen on Figure 3.4. Each blue area, has the commands to destroy vehicles and buildings that are inside of it.

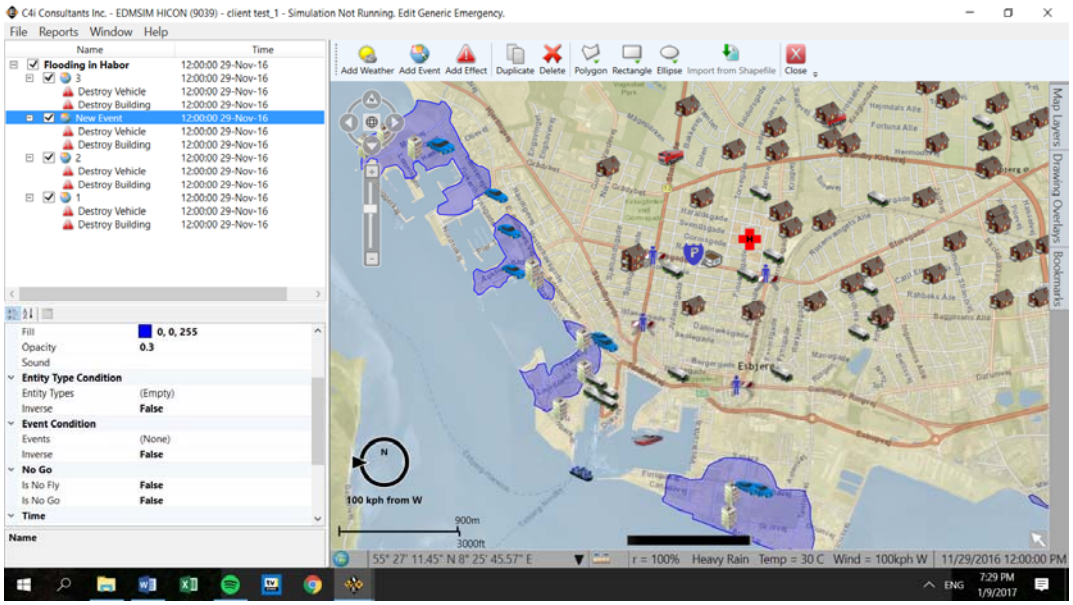

Figure 3.4. Harbor flooding.

Situation 1

As seen on Figure 3.5, the situational box event is placed in the map on top of the train station of the city of Bramming. At this point, a train travelling from Østerbro will stop, dismounting 80 people. Since the software does not have an option for train modelling, a bus is used instead. For the matter of simulation purposes, and graphic description is a well suitable option that would not affect the outcome. The situation will go further in development, according to the crisis unit response actions.

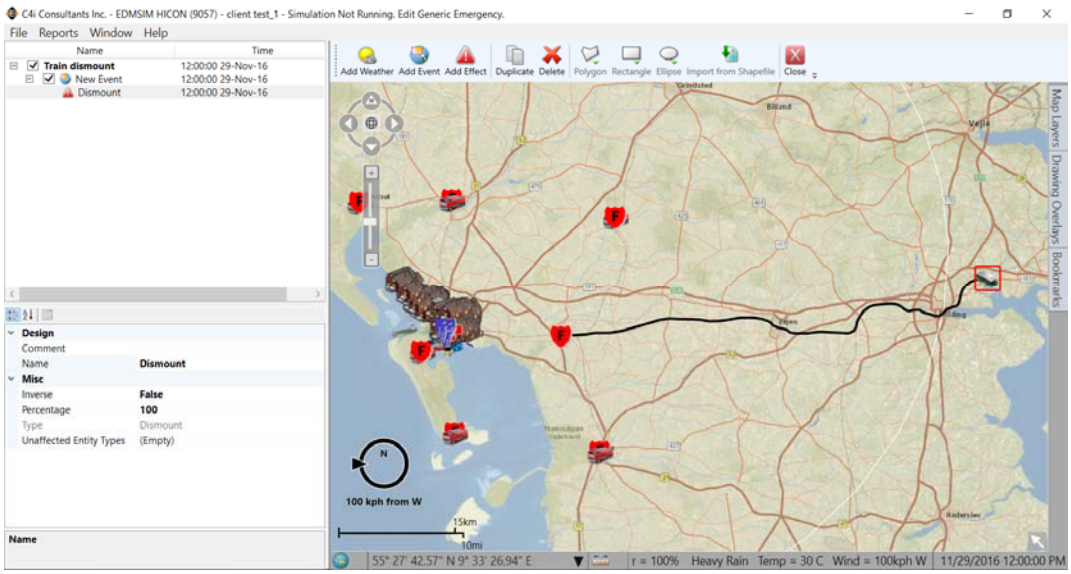

Figure 3.5. Passengers on train stopped at Bramming.

Situation 2

This is a situation simple to model on the software, which is represented as a service vehicle stopped at Sjelborgvej 22, as seen on Figure 3.6. Actions will carry on while the simulation is running, and the crisis unit take further measures.

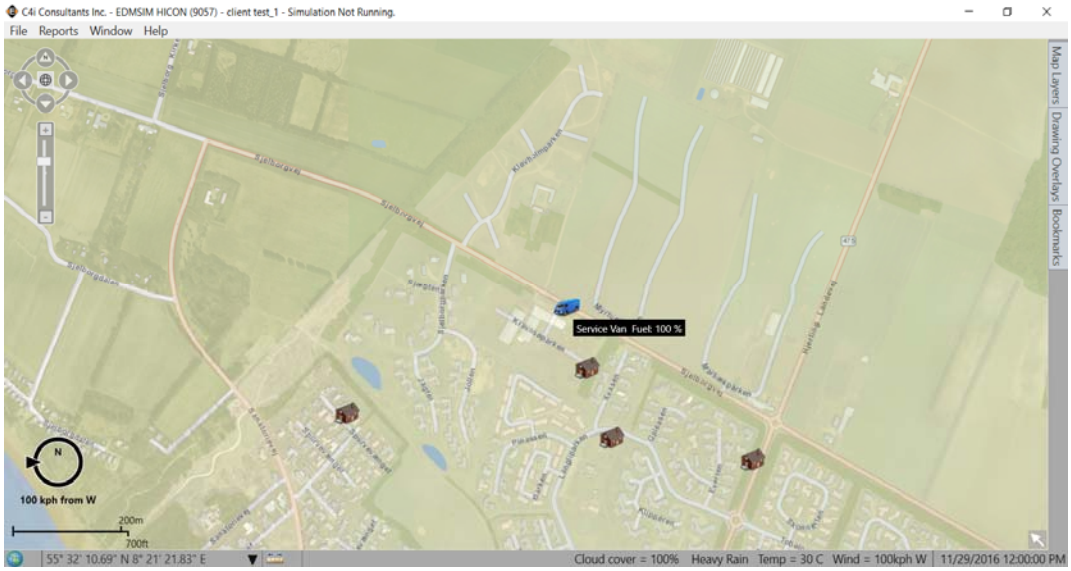

Figure 3.6. Service vehicle.

Situation 3

This is a situation similar to the previous in a simulation sense. A ferry is set on the map, to sail towards the harbour with 80 passengers on board as seen in Figure 3.7. Once it reaches harbour, management must deal with the actions taken in order to preserve the passengers well being.

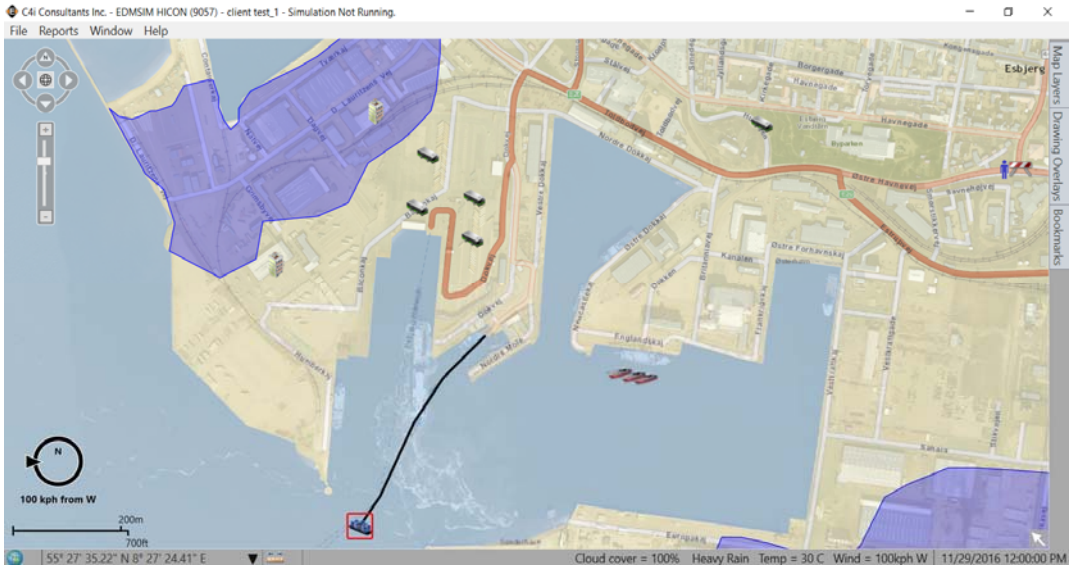

Figure 3.7. Ferry with passengers at harbor.

Situation 4

The simulation software is able to model an emergency in a school specifically. For this exercise, 480 people were situated inside the building. A generic scenario was assigned to destroy the building under a certain time frame as seen in Figure 3.8.

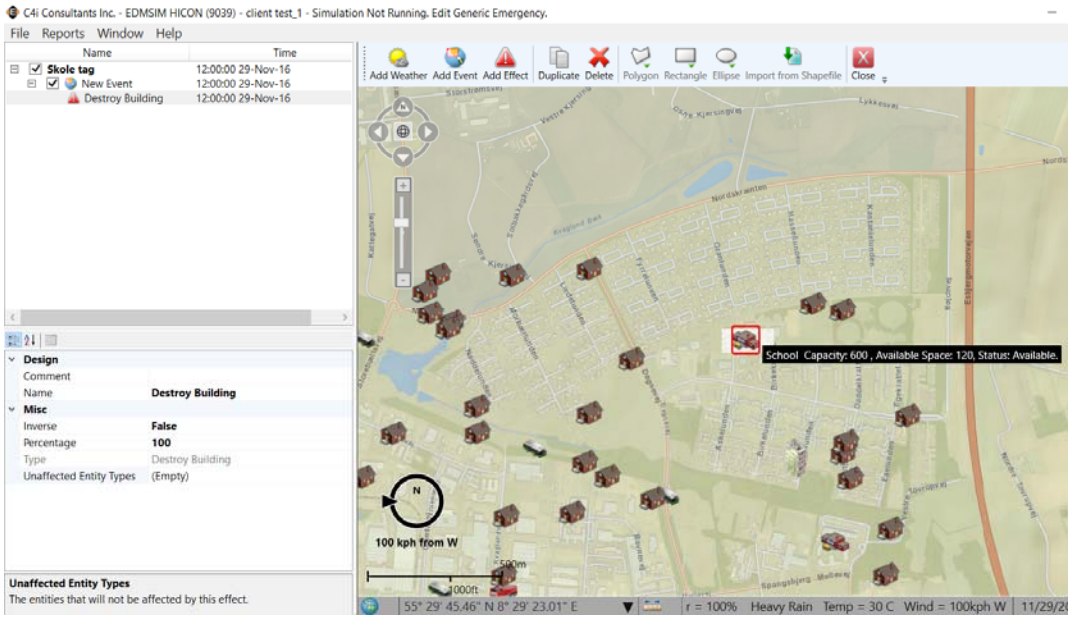

Figure 3.8. School roof damage.

Situation 5

The blackout at the Sønderris and Grønlandsparken was not possible to simulate for the consequence results. For this reason, the map on the software was used in this case, as a guide to show the power loss area as seen on Figure 3.9.

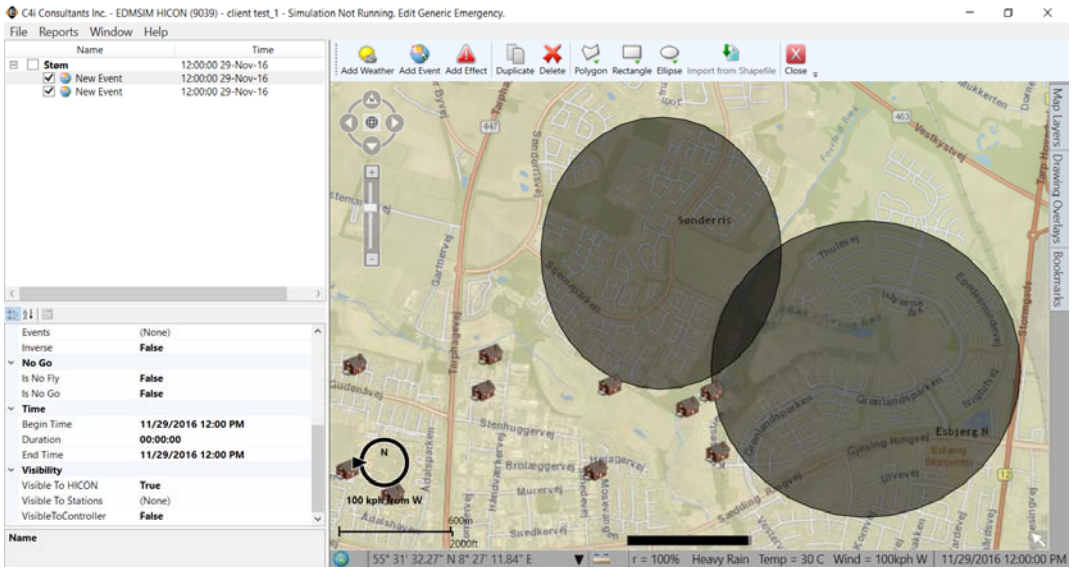

Figure 3.9. Blackout at Sønderris and Grønlandsparken.

Situation 6

Buses were added to drive around the city with passengers as seen in Figure 3.10. Some zones are affected by the storm such as the port and Jernbanegade, which is closed, affecting the circulation of the buses to the main station.

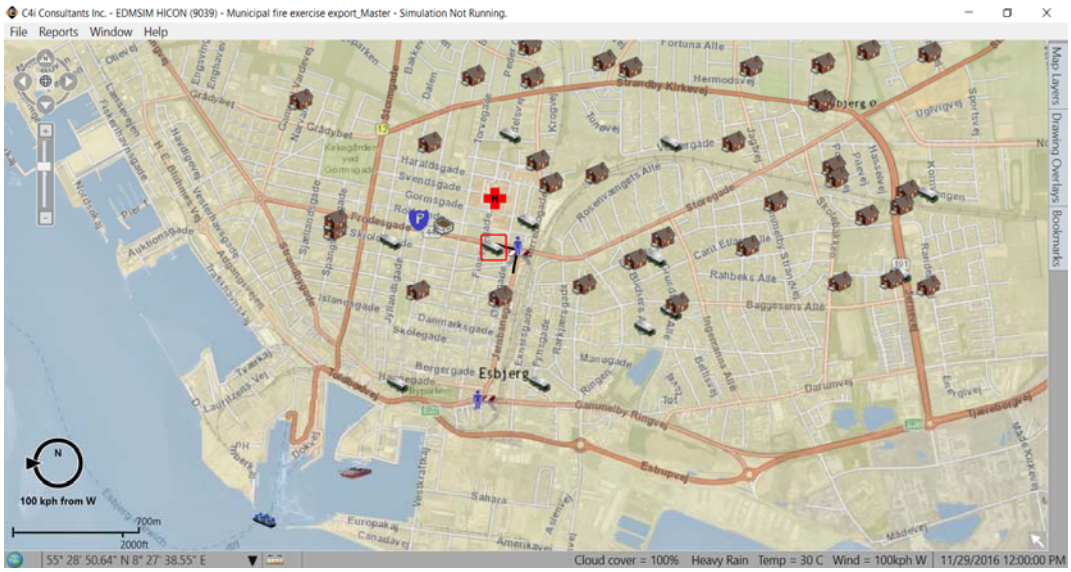

Figure 3.10. Buses around Esbjerg.

Situation 7

There is no need to model this situation on the software, given its nature.

Situation 8

Fire ignition command is added to a building at Cederlunden 21 as seen on Figure 3.11. Once the emergency command is activated, the fire will start to consume the building. Timing response will decrease the casualties and injured in the building.

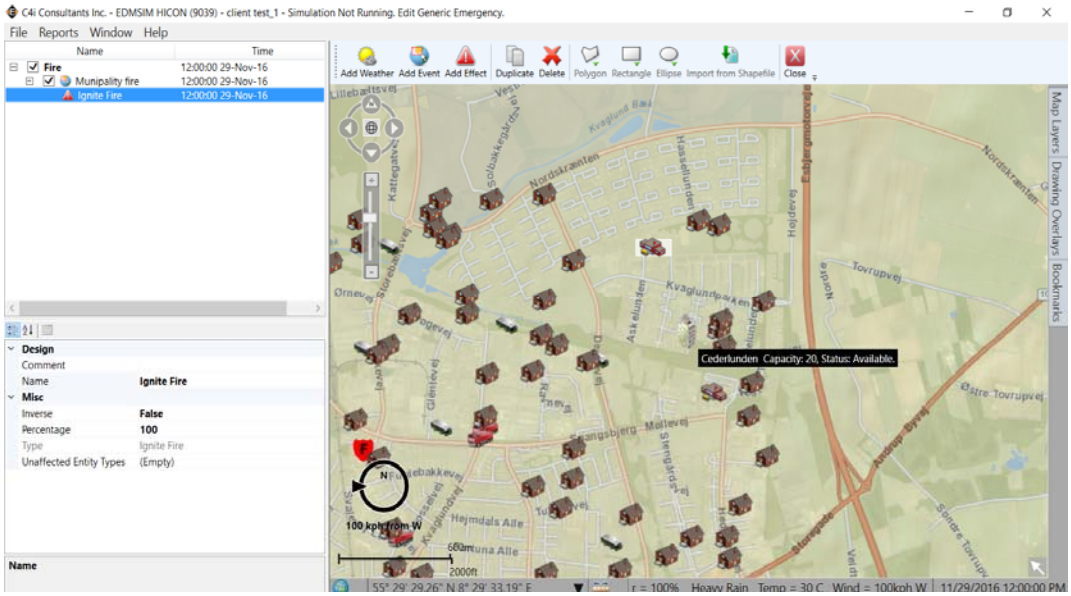

Figure 3.11. Fire at Cederlunden 21.

Situation 9

There is no need to model this situation on the software, given its nature. Although, the nursing home is physically placed on the map.

Situation 10

The dike flooding is represented with the blue color as seen in Figure 3.12. To represent some consequence results, a few buildings and cars were added to the flooding zone.

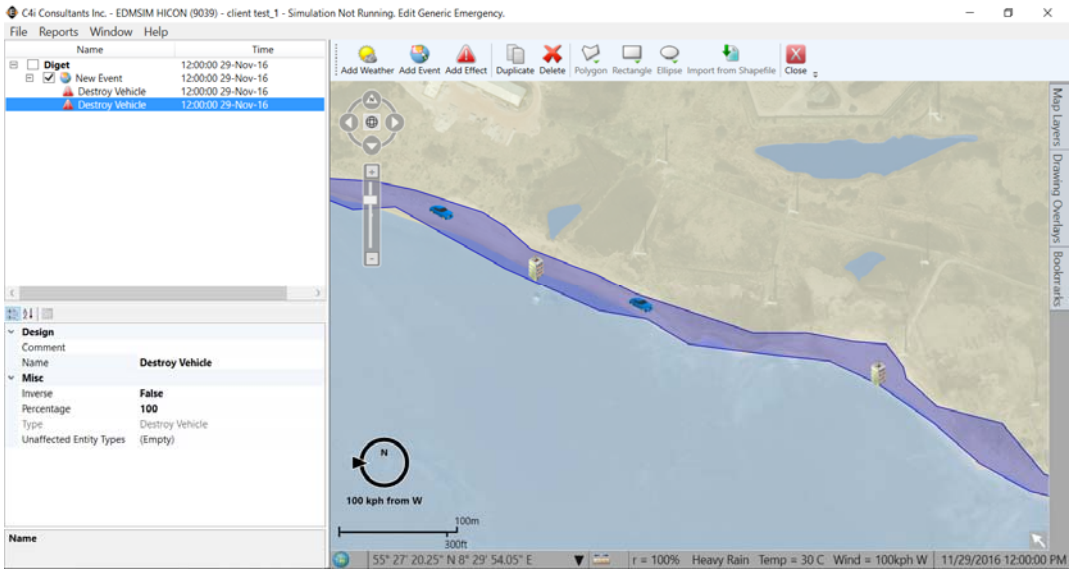

Figure 3.12. Darum dike flooding.

As seen above, some of these emergency scenarios have predetermined setups, and others do not. This means, that the situations are continuously carried on and develop over time, while the simulation is running live. The actions taken and the outcomes, depend entirely of the decisions made by the crisis unit.

This module, also allows the connection of other computers (entities) to the simulation, at the same time. This feature is thought for the communication training of the participating entities located in different places, whether it is police department, hospital, fire department and so on. It is obvious communication plays a significant role on the success of an emergency management, and it will be discussed later on.

Unit organization

The last window, is basically an inventory of all the items (units and sub units) present in the organization (emergency scenario) comprising the emergency situation as a whole, as seen on Figure 3.13. It allows, the creation and management of units for the simulation, customizable to the user's will and mission. From this window as well, units can be placed and dropped into the map. It is an overview of the items present, quantity, types and so on, in 1 window.

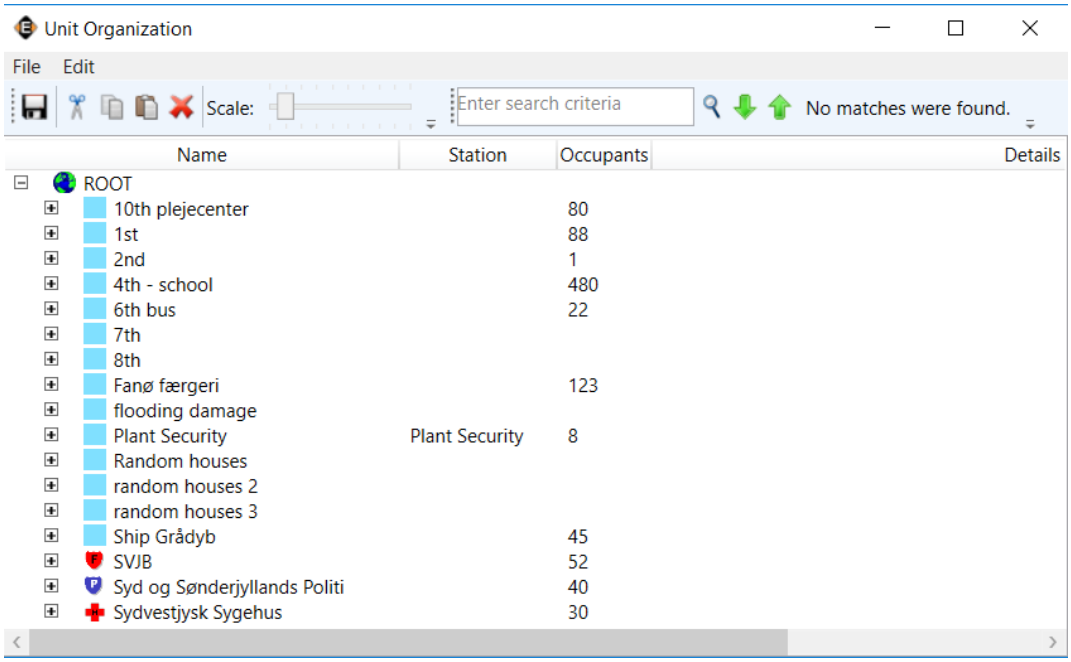

Figure 3.13. Unit organization window.

For the purpose of the investigation, each emergency situation component set were placed in a single unit, in the first place for organizational purpose and secondly, better management at the time of running the simulation. As seen on figure x, units subject to each emergency scenario are added separately along with correspondent response entities, such as the Esbjerg fire department, the Esbjerg police station and the Esbjerg hospital.

3.4 Mindset of the risk analysts

As risk analysts, before going into the emergency simulation exercise, several areas of interest were put into focus, such as coordination, leadership, communication, knowledge, decision making, and response time, given the fact this is where efficiency is easily overtaken. In one way or the other, all these aspects are connected to each other.

Coordination

It refers to working together as a whole unit in order to fulfil the decisions made, effectively and fast.

Leadership

All work groups have a leader, even if it is supposed for all members to have an equal status. Someone will always stand among the rest, and be heard the most. This can be good or bad. Good in the sense, that having just 1 voice of command can make the

coordination step more effective, avoiding having totally different views with no action taking. Also, to have someone to look up to and follow helps to hold together the group in order. Bad, in the sense that this person is not the most suitable to perform and fill this position, leading to bad decisions.

Communication

It could be one of the most important aspects in any work group. It regulates the response times and accurate information provided, for decision making and action taking. All the other aspects could be perfect, but not having the proper communication, the crisis unit team will end up in failure.

Knowledge

Each member has a defined role to take part on during an emergency situation, and each role has a curriculum to be fulfilled. This means, that not knowing the role position, can lead to inaccurate information, or delay times in order to find the correct answers. For this reason, the role actors must have full knowledge of their area.

Decision making

Once many of these aspects are followed, it comes down to the decision making. It takes a person or group of people to be sure the decisions made are the most suitable option. Also, to be ready to accept the consequences of such decisions. This phase, can affect the response times.

Response time

Emergency scenarios are situations that require fast response times. Time is crucial under these circumstances, since as time passes by, probability of failure increases. Response time is well tied to decision making, given that it does not mean success to have fast response times and bad decision making. And also, great decision making but long response time. To work in that thin line of equilibrium between these 2 is the goal.

As seen in this chapter, the emergency management setup was made alongside with the fire department of the city of Esbjerg, and the use of the EDMSIM software. This tool, not used before in the Risk and Safety Management program, takes time to understand and become a user, for this reason some explanation of the main working windows was necessary. Ten different emergency scenarios were added to one single simulation, using the tools provided by the software. Before going into the simulation exercise, the risks analysts must have a predetermine mindset in order to further analyze the performance of the crisis team, which take place in the next chapter.

4

Simulation exercise

On November 29th 2016 the executive board of Esbjerg Municipal was invited to a planned live exercise with SVJB. This was combined with a scheduled normal meeting for the executive board, with the information that an exercise would take place, but was not informed about the details of the exercise beforehand.

4.1 Participants

The executive board of Esbjerg Municipal was fully represented with all administration directors. Furthermore, there was representation from the crisis unit with one member as well as the head of joint crisis communication. The crisis unit members representing Varde and Fanø did not participate in the exercise. From SVJB The head of fire and rescue services as well as chief of operations was present. SVJB also provided a minutes keeper to present a realistic scenario. The participating members can be seen in Table 4.1.

Crisis unit	
Søren Abildtrup	Head of City Council Office (Crisis unit member)
Thomas Reil	Head of Communications (Head of joint emergency crisis communication)
Esbjerg Municipal executive board	
Otto Jespersen	City Manager Head of Joint administration
Arne Nikolajsen	Head of Health and Care administration
Lise Plougmann Willer	Head of Citizen and Job Market administration
Hans Kjær	Head of Engineering and Environment administration
Jørn Henriksen	Head of Children and Culture administration
SVJB	
Jens Mølgaard	Head of fire and rescue SVJB
Niels Strandvad Thomsen	Chief of operations
	Minutes keeper

Table 4.1. Participants.

It could be relevant in other scenarios to call and activate or warn additional members for support or to be on stand-by, as well as certain administrations might not necessarily be required to participate in a different situation setting. However, the participating members provides as realistic scenario where only crisis unit members from Esbjerg Municipal has been activated together with the relevant administrations.

4.2 Exercise progress

The participants were briefed by the head of fire and rescue services, Jens Mølgaard, in the adjacent meeting room to the operation room. Here Jens Mølgaard explained the emergency scenario for the last 24 hours leading up to the activation of the crisis unit in order to get all participants into game-mode. At the current state, the emergency level is at the highest level 3 - Operational Contingency. The full exercise briefing can be seen in appendix B. Together with the briefing the crisis unit is also updated on the current situation and risk picture report in accordance with the general emergency management plan as can be seen in appendix A

After the briefing the participants moved into the operation room where the chief of operations and minutes keeper already was doing game scenarios. A short introduction of the operation room and its functions, equipment, zones as well as the function of the simulation software. The emergency software EDMSIM was running of a personal computer and projected onto a 27” portable monitor placed on the table for all participants to see.

The games begins at 13:12 with the first input from Jens Mølgaard with the scenario 1 from chapter 3.1. A train is on its way to Esbjerg from Copenhagen with 80 passengers that will be stranded in Bramming due to trees on the train tracks. The Participants quickly starts discussing possible evacuation and relocation options. Schools are not an option due to the fact that there will still be active school children at this time. It is suggested to use Bramming culture and recreation center instead. Someone will need to be contacted to open the center, here the biggest risk is that at this time the center is unused and no janitor is present. Discussion goes on to showcase that there are multiple ways to enter the building. This can be done either by force, contacting the janitor, contacting personnel in the health care center, who would have access keys or exploring if the place has automatic fire prevention systems and key for the fire and rescue services to get in. Secondly it is also suggested to use the train station facilities to gather people and inform them collectively.

In regards to communication, a question is raised if it is even sound and secure to let people out of the train when the police advise against all unnecessary driving. This is something the LBS will decide and coordinate information about.

At this point a question is raised about how much operational decisions the crisis unit and executive board members will need to make. It is argued that this level of management is best handled by the fire and rescue services. Jens Mølgaard explains that SVJB are an extension of the municipal and that they will not start to make executive decisions that affect the municipal administrations without agreement with the board members. Therefore, it is important that the members are actively participating in the management response efforts and decision making with the support of SVJB. A joint effort in an emergency management situation, where the SVJB operational staff is highly taxed with incoming reports and tasks, it is important that certain tasks can be handed to the municipal crisis unit as a resource unit.

At 13:23 the next scenario 2 are presented to the game. A home nurse is calling SVJB because she can not get to her patient due to a tree blocking the road. Now a decision needs to be made if it is too dangerous for all home nurses to continue on their routes.

The discussion here moves towards the interpretation of the police message advising against all unnecessary driving and how this is to be interpret in the context of work related driving. There might be critical patients that need acute help, where a driving ban will need to be violated. This is an issue for many aspects and a clear recommendation from the municipal administrations is important in order to avoid a confusing and chaotic situation, were different institutions make own decisions. In an emergency scenario people will most often think about securing them self and their relatives. It is suggested to tell all active home nurses to stop routing, and escort home nurses to critical patients with police or firetrucks if possible. This also initiates a communication effort to patients waiting for a visit.

Another discussion sparked from this scenario, is that more and more treatments are placed in the patients private homes. This is an increasing trend and changes the healthcare emergency situation substantially.

13:35 Jens Mølgaard updates the municipal crisis unit with a new situation report.

At 13:38 an alert that part of a roof has blown of a school in Esbjerg city comes in as part of scenario 4. A unison decision a quickly formed to keep the children in school to avoid sending children outside and loosing track of children going home without parents consent.

Scenario 5 is reported immediately after at 13:44, that the power is lost in two arears of Esbjerg. The response here is to try to effectively communicate with citizens via different media. Again the most critical group are patients with emergency call that will be followed up on by the acute team associated with the hospital.

At 13:45 scenario 7 where the janitor of Esbjerg Municipal calls SVJB to ask if employees at the city hall can go home and how to act in regards to picking up children from school and kinder gardens. It is again underlined how much a coordinated communication effort matters in order to communicate that schools and other institutions should not send children home. The crisis unit would also coordinate with the local emergency team at the city hall to encourage employees from leaving outside.

Again the coordinated communication response is critical, since the crisis unit have experience with people not following recommendations made from the management. There is an understanding that public perception might go against what the emergency channels recommend.

The conclusion is that key persons should be kept available at the city hall to maintain incoming tasks, and the remaining staff should be encouraged to stay indoors for their own safety. The main issue is to reassure throughout the entire process that children are safely in the care of in schools.

At 13:53 the last scenario 10 is presented as the Darum dike it about to burst under the pressure from high waters. SVJB is requesting the help of the municipal to allocate resources for repairs and reinforcement of the dike. In case of rupture, efforts are to be coordinated with coastal authorities and the police.

The exercise ended up discussing seven of the ten proposed scenarios. The reason for excluding scenarios 6 and 8 was that it became apparent that they were more irrelevant for the strategic management to handle. Due to time constraints of the exercise, other scenarios where prioritized. Scenario 9 was presented to the crisis unit as a problem with the daily food delivery for elderly citizen living in their homes. The situation showed however that food delivery only happens once a week and citizens always has extra rations to last a couple of days without resupply. This would therefore not be an emergency scenario.

At 14:00 the game officially ends.

Observations

The exercise log produced by the SVJB minutes keeper is not available due to the fact that the exercise log is always deleted immediately after the exercise is finished.

During the exercise a lot of discussion of possible solution was made. In a real scenario this kind of discussion of best solutions, might not be ideal because fast decisions must be made to increase the impact of response and reduce the impact of the emergency. This exercise gave room for discussion and reflection because of a low consequence

setting and this is important to practice in order to perhaps make better informed decisions in a real emergency scenario.

The hierarchy during the discussions was very flat, everybody got a chance to suggest solutions to the scenario problems. Participants contributed very equally and there was a strong involvement and participation from the municipal directors.

For the purpose of this exercise was equally to introduce the executive board to the crisis room, setting and create situational awareness. It is important to focus on that the municipal management is there in a strategic function, and would delegate tasks and solutions to lower operational management in the different municipal administrations. The management knows the command structures and would be able to initiate a lot of moving pieces. However, the directors must also be prepared and willing to accept certain operational tasks, and should not be afraid to take responsibility in situations.

The simulation part of the exercise progressed as planned. It was proved harder to show consequences of decisions and actions during the exercise. This could be improved by changing exercise and scenario parameters for future exercises.

Communication turned out to be the most reoccurring issue. Communication both external with the public and internal with the municipal organization needs concrete and concise messages.

4.3 Evaluation of exercise

Post exercise it was not possible to do an evaluation with the municipal executive board members due to time constraints.

However, an immediate evaluation was done with Jens Mølgaard and Niels Thomsen who both expressed satisfaction with the completed exercise. There was a positive feedback on the results arrived at during the discussions, and a much more active participation from the participants than expected.

An immediate assessment was that the software could have been more useful with more consequence driven scenarios, where outcomes and consequences of choices would be more apparent.

Niels Thomsen expressed interest in using software in future exercises with a more operational focus. He additionally suggests to use it as in a live emergency scenario situation, as a live mapping, overview and resource tracking function. This could be done by having a super user that would be part of the operation room, inputting data and tracking logistical moving parts based on input from the operation staff.

For evaluation of the exercise with the municipal participants, a questionnaire was distributed to the 7 participants as seen in appendix C. The full questionnaire with answers can be seen in appendix D

Respondents rates the general exercise with an average score of 3 on a scale of 1-5. But all respondents found the exercise relevant.

Question 3 on if the exercise gave room for any afterthoughts about the emergency management situation. Respondents replies that it is a good idea to utilize exercises and practice during “peace time”, due to the fact that there were too many concrete questions they were not conditionally ready to answer.

Another respondent questions if they are really prepared in case of a real complex emergency situation. However, this person is confident in the competences of the SVJB to guide them through the situation.

Question 4 questions what the participants see as the outcome of the exercise. Here one respondent do not feel that they gathered any new awareness, except the realization that in a real scenario, the participants would be put under pressure in order to do decision making.

It was also made clear to respondents that there is a need for clarification of who is relevant to call and activate into the crisis unit in case of major emergencies. There is a realization that the executive board alone might not all be relevant players in a given scenario. It was also made apparent that a discussion with SVJB about what they concrete expect from the municipal members in order to match expectation. Most important is that the executive board supports the emergency response with what SVJB would need help with in any give emergency situation.

Question 5 asks if the newly storm warnings that was issued during 2016 Christmas and in the start of 2017 affected their thoughts on emergency preparedness after they had experienced the exercise. To this, one respondent answers no and another is surprised by how much effort and resources the society spends in a storm and flood warning situation. Continuing to question how high damages would be in case of a lack of emergency response. Lastly, the effort and participation of the many volunteers is applauded.

All respondents think that Esbjerg Municipal is prepared for an emergency, however, feels like there is room for improvement. And to question 7 respondents rates an average of 7.5 on a scale from 1-10 that it would be relevant to spend time and resources on yearly exercises.

All respondents followed the simulation on screen. One responds that it was difficult to see which made following what happened in the simulation and what the head of fire and rescue was reporting difficult. One respondent also think that there were too many interruptions from the participants. 50% of respondents felt that the simulation software helped create an overview and the other half did not.

Question 8c asks whether the participants think that implementation of simulation software can increase the positive outcome of an exercise on a management level. Here respondents asks for more clear guidelines in what the software does and are capable of due to the fact that is outside of their knowledge area. This highlights the importance of communication between levels in a crisis situation. They do however recognize the importance and necessity of using simulation software.

To what the participants think could help improve the exercise in question 9, respondents feel like more time and multiple levels of involved participants would help. Also both fewer, but more complex scenarios and multiple, but simple scenarios are suggested as improvements. One respondent points out that it is important with a mix of both complex and simple scenarios.

The last question 10 all respondents think that exercises are important in the future to improve resilience and emergency preparedness

5

FRAM
The Functional Resonance Analysis Method

Using FRAM developed by Erik Hollnagel to map the emergency management system, in order to analyze and understand the complexity of processes and interaction between functions in an emergency management scenario.

FRAM is developed for the medical industry to analyze work accidents by looking into how work is actually done and what affects a task. When dealing with work done by humans or any kind of organization, it is rarely following the exact guidelines, procedures, training or predefined design parameters that is thought out for a work process. This is the discourse between work-as-imagined and work-as-done, which comes from variability. Erik Hollnagel describes the function of FRAM as:

> *"FRAM provides a way to describe outcomes using the idea of resonance arising from the variability of everyday performance."* [45]

FRAM is a method for modelling "non-trivial socio-technical systems" to give a realistic representation of a complex and variable systems. Therefore, it is not a risk and hazard assessment or analysis method, but FRAM analysis can provide the understanding of a system in order to further analyze.

5.1 The basic principles of the FRAM

FRAM is based on four basic principles [46]:

1. The principle of equivalence (of successes and failures),
2. the principle of approximate adjustments,
3. the principle of emergence, and
4. the principle of resonance

The principle of equivalence means that both successes and failures can stem from the same root cause. In typical accident modelling a systems is typically taken apart and analyzed bit for bit at every level, in order to find a causality for an accident or a hazard. This means that there is a distinct difference between a well performing system

and malfunctioning system. In resilience engineering and FRAM the things that go wrong and the things that go right can occur in a very similar way. This is further explained by the second principle.

The principle of approximate adjustment accepts that in many socio-technical systems the conditions are ever changing and so complex that they can only be partially understood. This also means that work is often subjected to variability in the performance, under-performing and over-performing a system. This variability causes adjustments in the work performance (scheduling, tools, procedures, etc.), however this adjustment can only be approximate. Luckily, workers often have a lot of capacity to navigate systems and avoiding hazards, and in most situations this means that nothing happens. However, sometimes the approximate adjustments that makes things go right, is also the reason why a system fails.

The principle of emergent outcomes is based on the previous two principles and covers the fact that variability in a system will result in outcomes as emerging. Therefore, an outcome or causes are the result of untraceable groupings of events that exists because of navigating occurred variability.

The last *principle of resonance* is meant to explain the connection between variable events. Variability in a system can exist with or without affecting multiple functions or events. If a function is affected by variability it might spread to other functions as well and create resonance in the system. This means that doing linear cause analysis will not explain the emergence outcome.

This type of resonance is called *functional resonance* and is key to the FRAM.

When building a FRAM model, the goal is to describe how an activity takes place. This is done by defining the functions and activities, and the couplings that are necessary for the work or system to take place.

A function in FRAM is defined as [46]:

- *„A function typically describe what people – individually or collectively – have to do to perform a specific task and thus achieve a specific goal, for example, triage a patient or carry out medication reconciliation.*
- *A function can also refer to something that an organization does: for example it is the function of an emergency department to treat incoming patients.*
- *A function can refer to what a technical system does either by itself (an automated function, such as a dialysis machine) or together with one or more people (an interactive or socio-technical function, like an electronic health record).”*

Functions are describing the necessary activities to reach a goal, and are represented by a hexagon in the model as seen in Figure 5.1. A function have further six dimensions that are described as aspects, which detail how the function is performed.

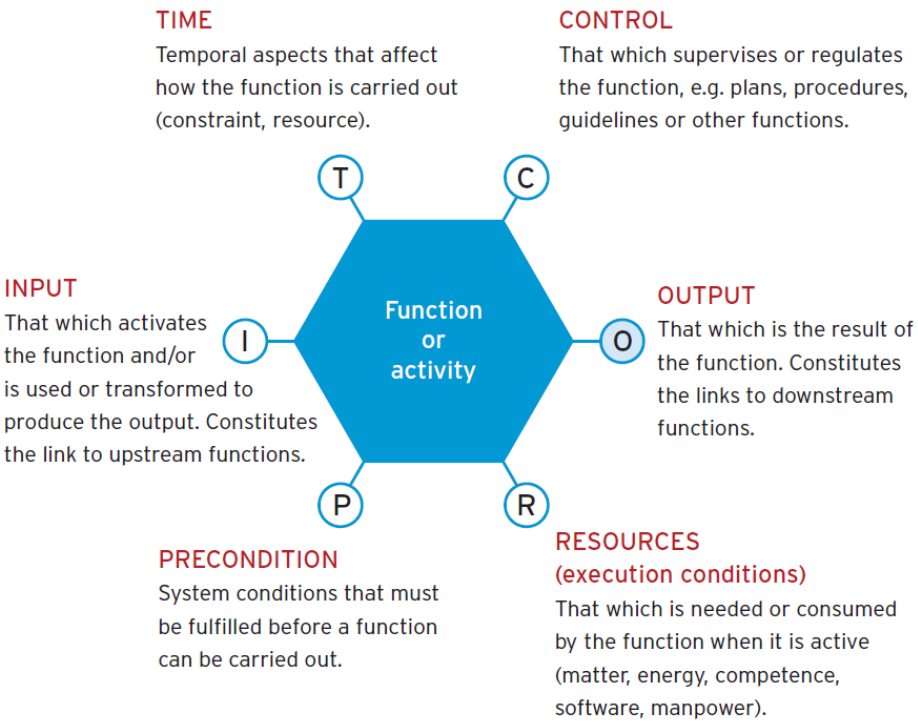

Figure 5.1. The six aspects of a function or activity [46].

5.2 FRAM model building

This model as seen in Figure 5.2 is created using the FRAM Model Visualiser available at functionalresonance.com.

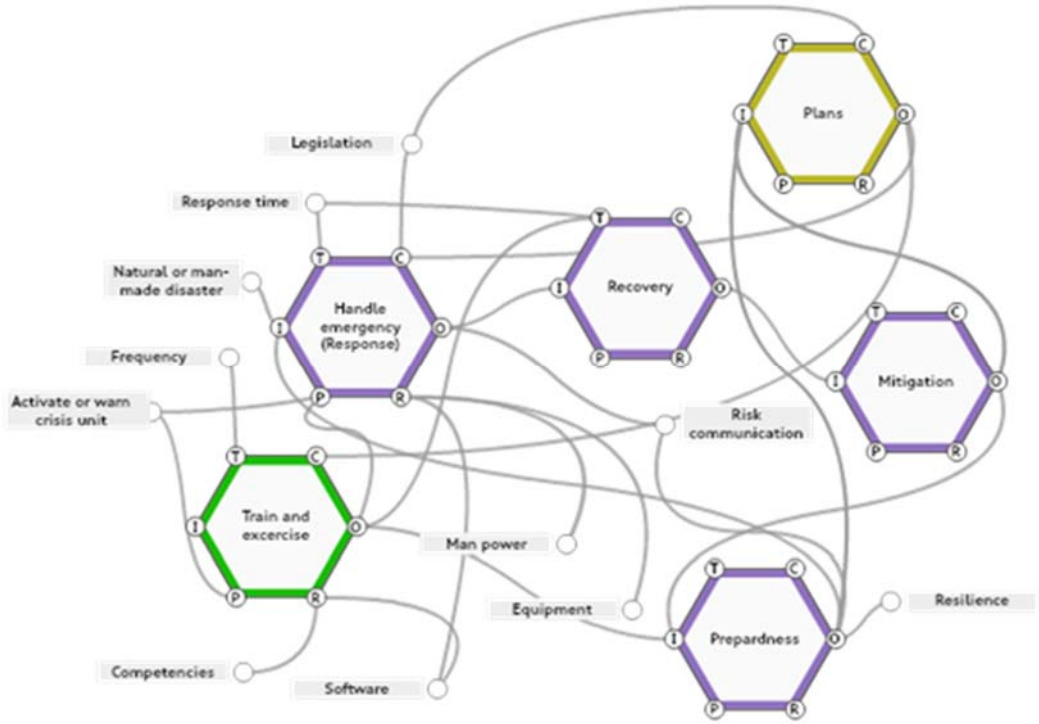

Figure 5.2. FRAM model of emergency management cycle.

The model is approached with the emergency management circle in mind with the phases preparedness, response, recovery and mitigation. These are used as function activities in the model and built around. For the purpose of this report, the model has an acceptable completeness level. Consistency could be improved by analyzing aspects of certain functions deeper, however, it is assessed that the necessary aspects have been defined.

Looking at the function of *Response* in Figure 5.3 it has two inputs of *natural or man made disaster* and the function *preparedness.* As a time aspect *response time* is affecting how fast any kind of response is able to handle an emergency. Response is also controlled by a *legislation* aspect and *plans* function since the response should correspond to the predefined plans. Preconditions for the response function are *activating or warning the crisis unit* which will need to be aware of the situation before being able to make any response and *training and exercise* should also be a precondition in order to form a appropriate response. Multiple resources can be attributed to the response, *man power, equipment and software* have been defined in this model. The output of this function are *Recovery* and *risk communication.*

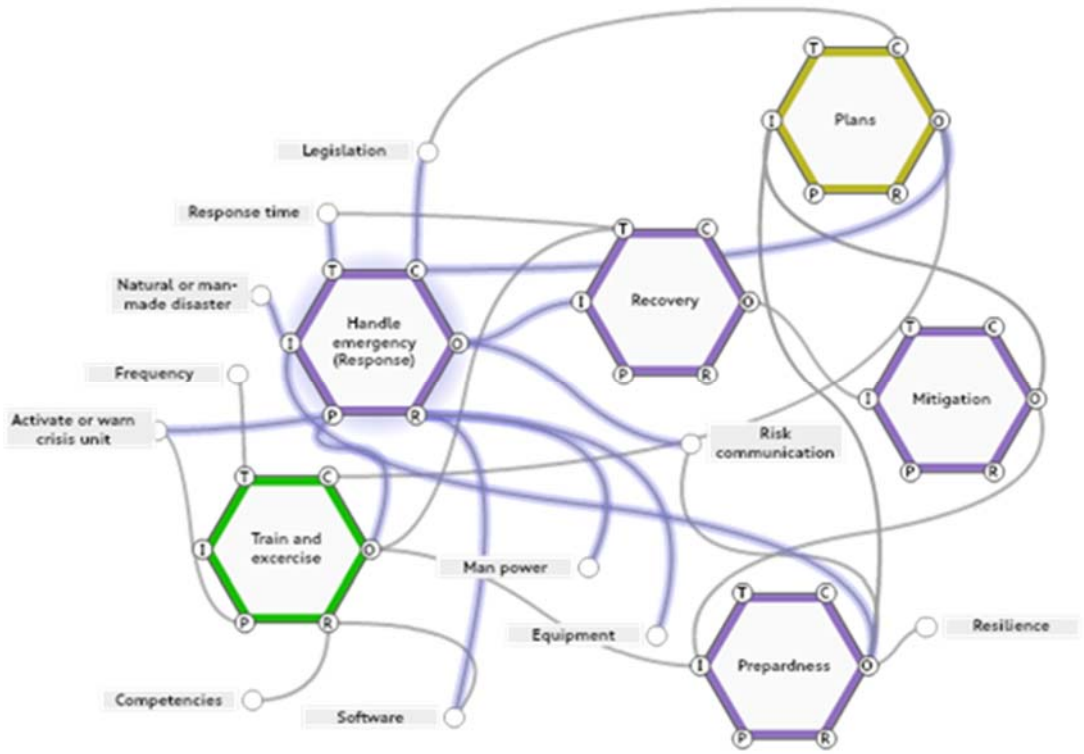

Figure 5.3. FRAM model – Response function couplings.

Looking at the *Training and exercise* function in Figure 5.4 it has a time aspect of *frequency*, meaning that the quality of training is based on how often a crisis unit will be put through an exercise scenario. A control aspect is *plans* as proper emergency plans will regulate the output of the exercise. Again for this function the precondition to *activate or warn crisis unit* is needed in order to gain any value in a training exercise. As resources are *competencies* and *software*, since it is very important to have competent members to lead an exercise, evaluate and implement improvements. In a training activity *software* can be a very useful resource to improve the outcome of the activity. There have been defined three outcomes of the activity, first outcome is as a precondition for the *Response* function. Second is a time aspect for the *Recovery* function, and the last is an input for the *Preparedness* function.

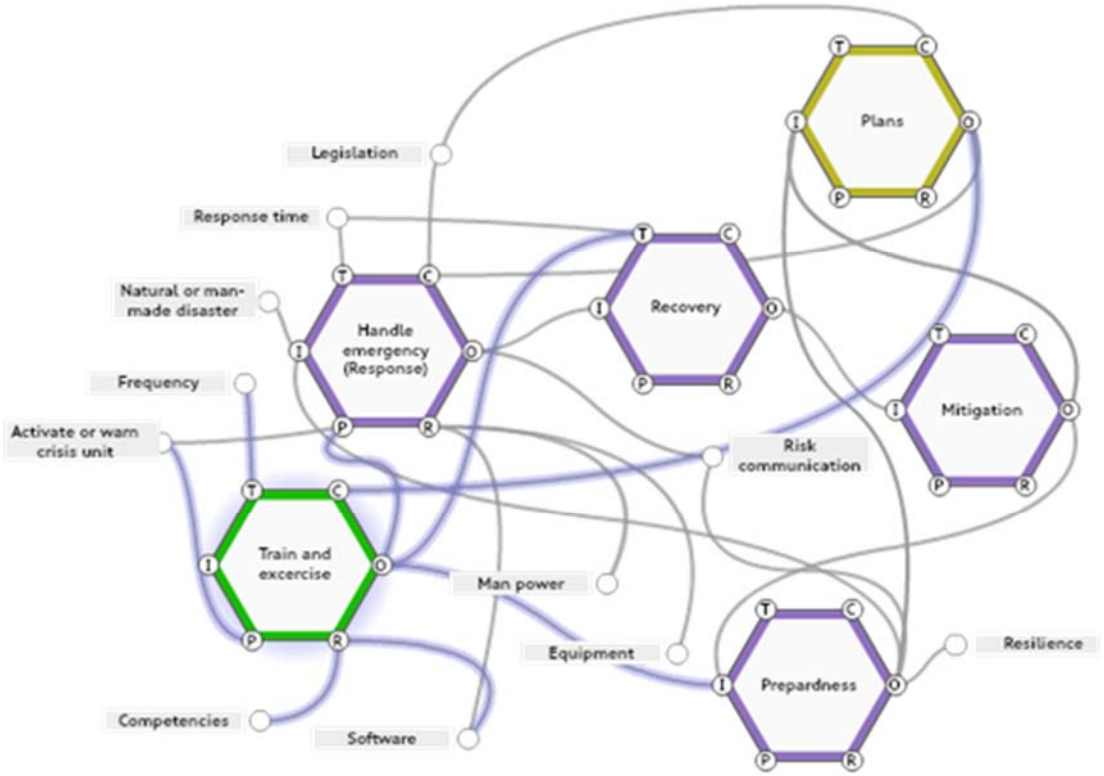

Figure 5.4. FRAM model – Training and exercise function couplings.

The *Recovery* function as seen in Figure 5.5 starts with an input from the *Response* function. There are two time aspects present represented by *response time* and the *train and exercise* function. Proper response time and effective training will both be able to reduce recovery time in an emergency scenario. Recovery has one output, in this model it starts the input for the *mitigation* phase.

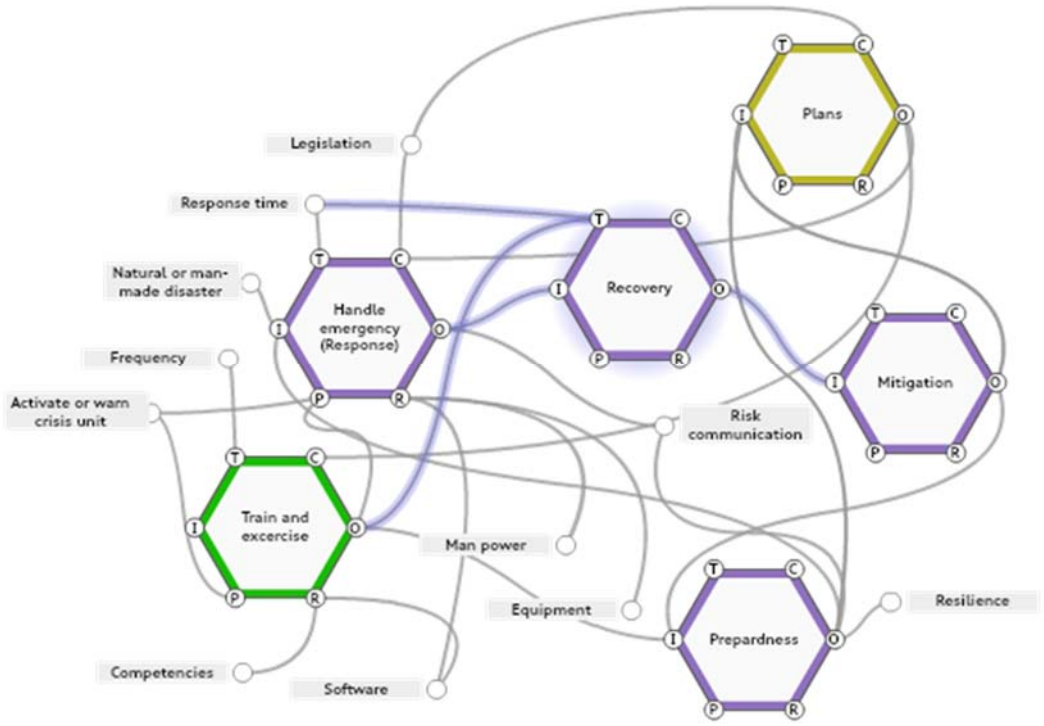

Figure 5.5. FRAM model – Recovery function couplings.

The *mitigation* activity as seen in Figure 5.6 is not deeply investigated in this report and therefore only uses input and output aspects. The input comes from the *recovery* function. The mitigation activity produces two outputs, both inputs for the *plan* and *preparedness* activities.

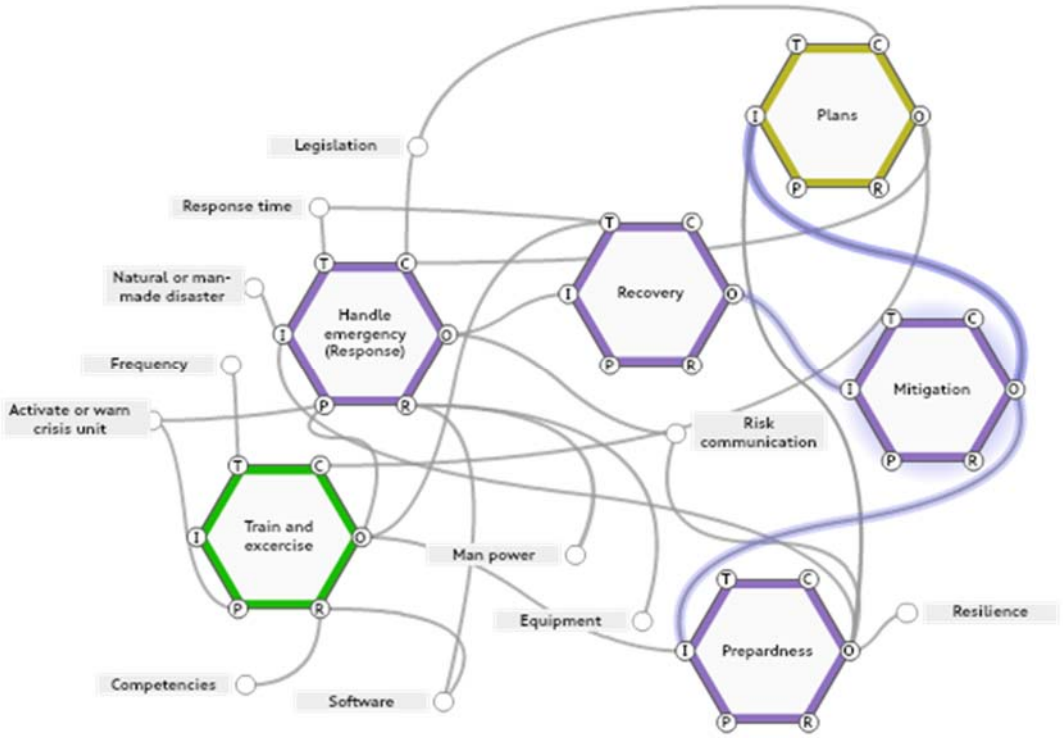

Figure 5.6. FRAM model – Mitigation function couplings.

Looking at the *preparedness* activity in Figure 5.7 it has two inputs. First the *train and exercise* activity is able to activate a preparedness phase at any point in a cycle, secondly the output of *mitigation* should be to increase this function. Preparedness has four outcomes being, *response, risk communication, plans* and *resilience.* It can be argued that resilience is a goal of most activities in an emergency management system, but for simplicity, it is only represented as an outcome from the *preparedness* activity.

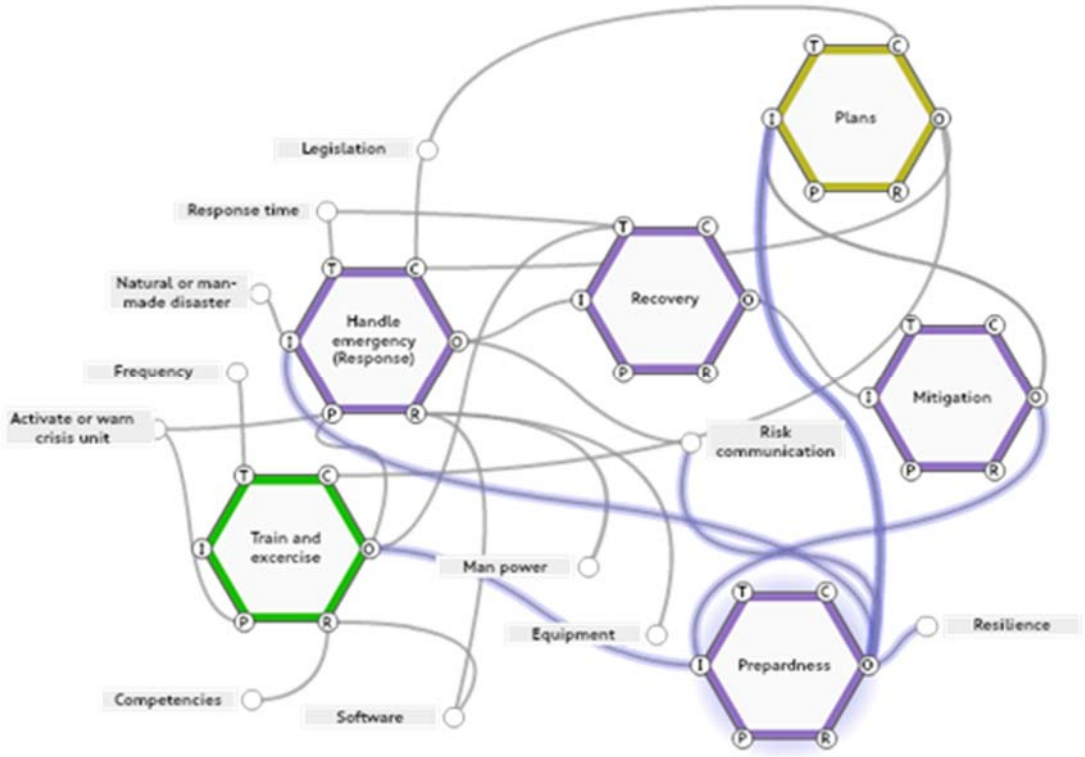

Figure 5.7. FRAM model – Preparedness function couplings.

5.3 FRAM model analysis

As is can be seen from the above analysis, the emergency management system is very integrated with many aspects and functions embedded. The system is also filled with a lot of inherent variability.

There is possibility to see a lot of functional resonance between the activities when the emergency systems moves from phase to phase. Many moving parts in each activity means that a lot of variability can be moved within the system, creating resonance in each phase. *Response time* is a large variable factor that can create large amounts of resonance between and in the *response* and *recovery* functions. An effort in recovery can be highly affected by the response time. The faster a system or activity can return back to normal (pre-disaster) the higher resilience the system entails. Measuring the resilience can be done by looking at the concept of *loss triangle* as seen in Figure 5.8.

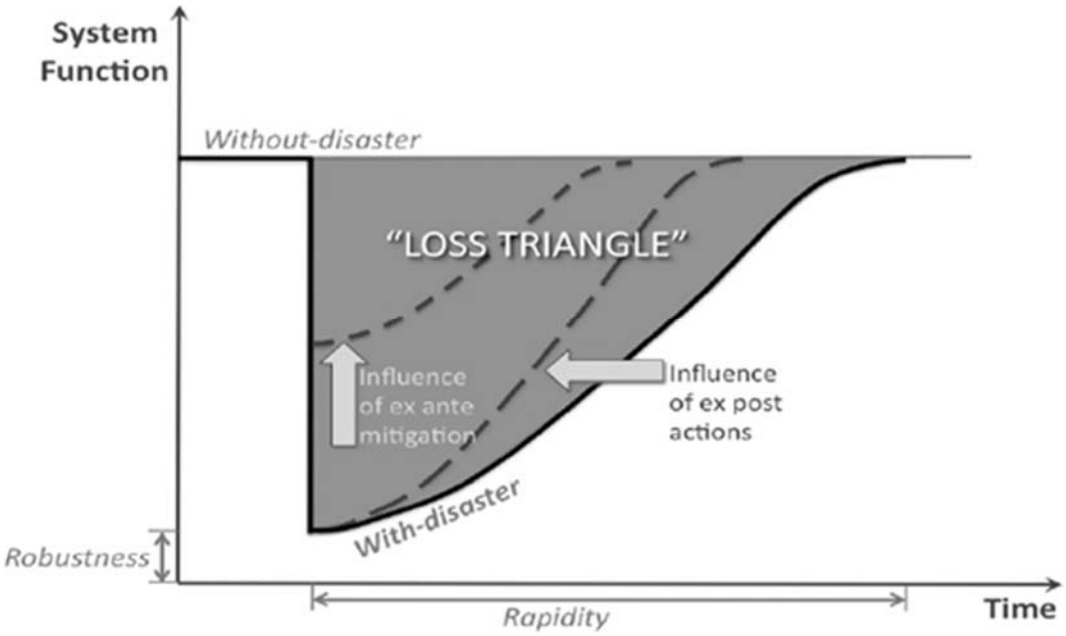

Figure 5.8. Measuring resilience using the "Loss Triangle" concept [47].

The black line shows the effort it takes to return to normal conditions during and after a disaster. The long dotted line shows the recovery time and effort can be shortened by effective and quick response time.

To improve resilience and reduce recovery time even more, a focused effort should be put on the previous mitigation and preparedness phases, there the short dotted line represents a very robust system that is not affected nearly as much by the disaster and can therefore recover in record time.

A lot of effort is put into making systems more resilient and robust today. Looking at the IMPROVER Project, at a European level an effort is put into improving the resilience of critical infrastructure and knowledge sharing [2].

The best way to control the variability and lessen the possible bad emergent outcomes, is for the management to train and exercise. By training and testing both the system and management will improve its capacity to amplify positive variability, thus strengthening resilience. However a holistic approach must be kept in mind, since focusing only on improving one function, e.g. *plans* will not necessarily result in an increased resonance capacity for the response. This although the system is so integrated. The training must also be recorded and studied; focus should be on implementation and learning. Risk communication as seen from the exercise in chapter 4, is also an activity with a huge variability but also affected by variables input.

This FRAM model is not representing a completely developed analysis, and it can always be further detailed or simplified, as well as focused on different and more functions and aspects. A weakens of the FRAM is that the model quickly loses

overview and can become hard to grasp. It could be relevant or appropriate to divide the system analysis into different stages and levels, in order to have a more detailed look into the resonance of certain functions. However, this report will keep a simple overview focus on the emergency management process and further analysis work is encouraged.

6

Conclusion

Emergency management is a complex system with several and different parts, within any given industry. It takes all these parts to perform at their best and work together to be successful. Every phase of the emergency management as a whole is equally important, from the actors taking part in the crisis unit, the design of emergency plans to the overview and update of current practices.

Reviewing the preparedness phase of the municipality and fire department of the city of Esbjerg, it was clear to observe that regarding logistics for the crisis unit they were well prepared. Documentation on the organizational level, (names, phone numbers, job position, and so on) was available and self-explanatory. Also, communication systems (radios, phone lines, crisis room) were easy to understand. Nonetheless, a lack of documentation on the operational level was palpable, for example what are the steps to follow under emergency circumstances. One thing to understand is that, not everyone think alike, for this reason, a standardization or steps to follow during a crisis (in an operational level) is important to have present in such organizations.

This aspect leads to the results obtained during the exercise. The time response in the decision making was slow, which, as said before in this investigation, is such an important factor for success and consequence mitigation. Roles and hierarchy of command, was also short. One of the causes to attribute this, are that in one hand, this was the first time such team got together to participate in an event of this nature. And on the other, it is a resulting consequence of the matter explained before, which is the lack of a guide to follow in crisis events. So, improvements come with practice, and all tools available to asses this matter are a plus, this where the simulation software comes into play. EDMSIM, is considerable helpful for emergency simulation practices, not only in a sense for graphical understanding of the situation, but more importantly as a consequence quantifiable asset, since different decision making times and type of decisions can result into different outcomes. Also, the fire department for their exercise practices, uses actual paper maps of the city, where with the use of the GPS system integrated in the software, and all the other features available are a considerably large improvement in such practices.

To finalize, as seen in the live exercise with the crisis unit, there is room for improvement in many aspects, and it can be achieved with more exercise practices, in order to allow the actors to get more experienced with the tasks they are in charge of; hence feeling more comfortable in the decision making phase, creating capacity for work and reducing response times as well as incrementing emergency solutions quality.

There is still room for improvement and future work, with analysis of the emergency management systems and subsystems. The FRAM analysis shows the importance of a deeper understanding of an emergency management situation, and an increased focus on finding and controlling variables that affect resilience.

Bibliography

[1] The OFDA/CRED International Disaster Database, "Disaster Trends," 19 07 2016. [Online]. Available: http://www.emdat.be/. [Accessed 20 10 2016].

[2] IMPROVER, "Project description," 01 06 2015. [Online]. Available: http://improverproject.eu/discover/. [Accessed 12 12 2016].

[3] United Nations Office for Outer Space Affairs, "Benefits of Space: Human Settlements," [Online]. Available: http://www.unoosa.org/oosa/en/benefits-of-space/human-settlements.html. [Accessed 21 10 2016].

[4] Beredskabsstyrelsen , "Seest-ulykken 10 år efter," 03 11 2014. [Online]. Available: http://brs.dk/omstyrelsen/presse/nyheder/Pages/2014_11_03_seest-ulykken-10-aar-efter.aspx. [Accessed 19 10 2016].

[5] S. Wittrup, "Brandslukning på Avedøre krævede 170 ton CO2 og luk af Øresundstunnelen," 19 09 2012. [Online]. Available: https://ing.dk/artikel/brandslukning-paa-avedoere-kraevede-170-ton-co2-og-luk-af-oeresundstunnelen-132344. [Accessed 22 11 2016].

[6] S. Wittrup, "Eksplosion på Avedøreværket gav trykbølge af støv og gnister," 19 10 2016. [Online]. Available: https://ing.dk/artikel/eksplosion-paa-avedoerevaerket-gav-trykboelge-stoev-gnister-187630?utm_source=nyhedsbrev&utm_medium=email&utm_campaign=daglig&cx_newsletter=daglig&cx_newsletterid=186889. [Accessed 22 11 2016].

[7] Beredskabsstyrelsen , "Indsats ved storbrand i Fredericia," 04 02 2016. [Online]. Available: http://brs.dk/omstyrelsen/presse/nyheder/Pages/2016_02_04_storbrand-i-fredericia-under-kontrol.aspx. [Accessed 19 10 2016].

[8] Berlingske, "Her er de 5 værste orkaner," 01 09 2008. [Online]. Available: http://www.b.dk/verden/her-er-de-5-vaerste-orkaner. [Accessed 02 12 2016].

[9] DMI, "Decemberorkanen 1999: Da Danmark fik en over nakken," 16 11 2012. [Online]. Available: https://www.dmi.dk/laer-om/temaer/vejr/decemberorkanen-1999/. [Accessed 22 11 2016].

[10] Beredskabsstyrelsen, "Etablering af nye beredskabsenheder inden for det kommunale redningsberedskab," 03 05 2016. [Online]. Available: http://brs.dk/beredskab/idk/kommunalt_beredskab/sammenlaegning-af-kommunale-redningsberedskaber/Pages/default.aspx. [Accessed 17 10 2016].

[11] KL, "Juridiske rammer for etablering af beredskaber," 20 09 2014. [Online]. Available: http://www.kl.dk/ImageVaultFiles/id_69383/cf_202/Juridiske_rammer_for_etablering_af_beredskaber.PDF. [Accessed 15 10 2016].

[12] R. Berth, L. Markert, M. Graff and L. Skovgaard, "§ 60-Fælleskaber," 10 12 2014. [Online]. Available: http://www.slideshare.net/HortenLawFirm/seminar-om-60-fllesskaber-101214. [Accessed 20 10 2016].

[13] KL, "Kort over nye beredskabsenheder," 11 04 2016. [Online]. Available: http://www.kl.dk/Kommunale-opgaver/Teknik-og-miljo/Trafik-og-veje/Beredskab/Beredskabskort-/. [Accessed 20 10 2016].

[14] Esbjerg Havn , "Presse - Tal og Fakta," [Online]. Available: http://portesbjerg.dk/da/nyheder-presse/presse. [Accessed 19 10 2016].

[15] Esbjerg Havn, "Arealudlejning – tal og fakta," [Online]. Available: http://portesbjerg.dk/da/havnearealer/havnearealer-%E2%80%93-tal-og-fakta. [Accessed 19 10 2016].

[16] Esbjerg Havn, "Tal & fakta," [Online]. Available: http://portesbjerg.dk/da/om-esbjerg-havn/tal-fakta. [Accessed 19 10 2016].

[17] Esbjerg Havn, "Financials 2011 - 2015," [Online]. Available: http://portesbjerg.dk/en/annual-reports/financials-2011-2015. [Accessed 02 01 2017].

[18] Esbjerg Havn, "2015 i hovedtræk Årsrapport Esbjerg Havn," [Online]. Available: http://portesbjerg.dk/sites/default/files/aarsrapport_2015_da.pdf. [Accessed 15 12 2016].

[19] Esbjerg Kommune, "Esbjerg Kommune - "Tal og fakta" - Areal og befolkningsforhold - Indbyggertal og Personer med udenlandsk herkomst," 01 01 2015. [Online]. Available: http://www.esbjergkommune.dk/om-kommunen/tal--fakta-og-historie/fakta-om-kommunen.aspx. [Accessed 20 10 2016].

[20] Esbjerg Kommune, "Esbjerg Kommune - "Tal og fakta" - Undervisning og uddannelse - Studerende på videregående uddannelser," 01 09 2014. [Online]. Available: http://www.esbjergkommune.dk/om-kommunen/tal--fakta-og-historie/fakta-om-kommunen.aspx?r_=0.2485812968063023#Sociale_forhold. [Accessed 20 10 2016].

[21] Esbjerg Kommune, "Esbjerg Kommune - "Tal og fakta" - Undervisning og uddannelse - Folkeskolen for skoleåret og Private skoler for skoleåret," 2014/2015. [Online]. Available: http://www.esbjergkommune.dk/om-kommunen/tal--fakta-og-historie/fakta-om-kommunen.aspx?r_=0.2485812968063023#Undervisning_og_uddannelse. [Accessed 20 10 2016].

[22] Esbjerg Kommune, "Esbjerg Kommune - "Tal og fakta" - Areal og befolkningsforhold- Befolkningens aldersfordeling," 01 01 2015. [Online]. Available: http://www.esbjergkommune.dk/om-kommunen/tal--fakta-og-historie/fakta-om-kommunen.aspx. [Accessed 20 10 2016].

[23] Fanø Kommune, "Folketal, Areal og beskatning," 01 01 2016. [Online]. Available: http://www.fanoe.dk/kommunen/fakta-om-kommunen/folketal--areal-og-beskatning. [Accessed 20 10 2016].

[24] Varde Kommune, "Fakta om Varde Kommune," 01 01 2016. [Online]. Available: http://www.vardekommune.dk/fakta-om-varde-kommune. [Accessed 20 10 2016].

[25] Sydvestjysk Brandvæsen, "Risikobaseret dimensionering Sydvestjysk Brandvæsen 2016," 20 12 2015. [Online]. [Accessed 06 01 2017].

[26] Institution for Economics & Peace, "Global Peace Index 2016," 06 2016. [Online]. Available: http://static.visionofhumanity.org/sites/default/files/GPI%202016%20Report_2.pdf. [Accessed 20 10 2016].

[27] Bündnis Entwicklung Hilft and United Nations University – EHS, "World Risk Report 2016," 2016. [Online]. Available: http://weltrisikobericht.de/wp-content/uploads/2016/08/WorldRiskReport2016.pdf. [Accessed 20 10 2016].

[28] Beredskabsstyrelsen , "Redningsberedskabet i Danmark," 02 02 2016. [Online]. Available: http://brs.dk/beredskab/idk/redningsberedskabet_i_danmark/Pages/RedningsberedskabetiDanmark.aspx. [Accessed 20 10 2016].

[29] Beredskabsstyrelsen, "Nationalt Risikobillede (NRB)," 09 04 2013. [Online]. Available: http://brs.dk/viden/publikationer/Documents/Nationalt_Risikobillede.pdf. [Accessed 20 10 2016].

[30] Beredskabsstyrelsen, 02 02 2016. [Online]. Available: http://brs.dk/beredskab/idk/redningsberedskabet_i_danmark/Pages/RedningsberedskabetiDanmark.aspx. [Accessed 02 12 2016].

[31] "The Emergency Management Act," 02 07 2009. [Online]. Available: http://brs.dk/eng/legislation/act/Pages/the_emergency_management_act.aspx#Part3. [Accessed 02 12 2016].

[32] Esbjerg Kommune, "Beredskabskommissionen," [Online]. Available: http://www.esbjergkommune.dk/politik/andre-r%C3%A5d-og-udvalg/beredskabskommissionen.aspx. [Accessed 02 12 2016].

[33] SVJB, "Generel beredskabsplan 2016 - Esbjerg, Varde og Fanø kommuner," 2016.

[34] D. Alexander, How to write an emergency plan, Edinburgh: Dunedin, 2016.

[35] DEMA, "Sirenevarsling," 10 08 2016. [Online]. Available: http://brs.dk/beredskab/varsling/Pages/Varsling.aspx. [Accessed 01 01 2017].

[36] Beredskabsforbundet, "AFPRØVNINGEN AF SIRENERNE.," 06 05 2016. [Online]. Available: http://bf-syddanmark.dk/nyheder/nyheder-fra-region-syddanmark/nyhed/article/afproevningen-af-sirenerne/. [Accessed 01 01 2017].

[37] Mobilvarsling, "Om MOBILVARSLING," [Online]. Available: http://www.brs.dk/beredskab/varsling/mobilvarsling/om-mobilvarsling/Pages/om-mobilvarsling.aspx. [Accessed 01 01 2017].

[38] Esbjerg Kommune, "@EsbjergK," [Online]. Available: https://www.facebook.com/EsbjergK/. [Accessed 07 01 2017].

[39] Esbjerg Kommune, "@EsbjergKommune," [Online]. Available: https://twitter.com/esbjergkommune?lang=en. [Accessed 07 01 2017].

[40] Esbjerg Municpal, "@EsbjergKommune," 26 12 2016. [Online]. Available: https://twitter.com/EsbjergKommune/status/813390616155582465?lang=en. [Accessed 07 01 2017].

[41] Esbjerg Kommune, "***STORM OG FORHØJET VANDSTAND***," 26 12 2016. [Online]. Available: https://www.facebook.com/EsbjergK/posts/1238719682861734. [Accessed 07 01 2017].

[42] Teknologirådet, "Danmarks nye katastrofeberedskab under lup," *Fra Rådet til Tinget,* no. 248, pp. 1-5, 2008.

[43] CFB, "Dækning," [Online]. Available: http://www.sikkerhedsnet.dk/om-sine/nettets-opbygning/daekning/. [Accessed 12 12 2016].

[44] CFB, "Nettets opbygning," [Online]. Available: http://www.sikkerhedsnet.dk/om-sine/nettets-opbygning/. [Accessed 12 12 2016].

[45] E. Hollnagel, "A brief introduction to the FRAM," [Online]. Available: http://functionalresonance.com/brief-introduction-to-fram/index.html. [Accessed 01 01 2017].

[46] E. Hollnagel, "The Fram Handbook," [Online]. Available: http://www.centerforkvalitet.dk/wm447734. [Accessed 11 10 2016].

[47] National Research Council, National Earthquake Resilience: Research, Implementation, and Outreach, Washington, DC: The National Academies Press, 2011.