National
Risk Profile
for Denmark

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Preface

In Denmark, a wide range of authorities and organisations help to ensure the safe, smooth running of society. It is not without reason that we can enjoy a good general level of health, a stable supply network and a reliable infrastructure. Even in our society, however, major accidents and disasters do occur, and we need to have effective emergency management in place to deal with them.

While some of the incidents that befall us are well-known, there are others about which we know less. Only rarely are we completely surprised by an incident that falls outside of what we had imagined possible. When preparing to deal with extraordinary incidents, it makes sense to start with the risks that we know are present. We must never allow ourselves to be thrown off balance by these. In preparing for the known, we also gain skills and capacities that could also prove useful to us the next time something new and unexpected occurs.

I am delighted to present the second edition of the National Risk Profile. A lot has happened since the Danish Emergency Management Agency (DEMA) published the National Risk Profile for the first time well over three years ago. The product sparked a great deal of interest and became widely used. The time is now ripe for an updated version, and in this edition we have concentrated on providing readers with an even deeper understanding of the incident types and the challenges they present in terms of overall emergency management.

This publication draws attention to 13 incident types. Common for all is that an exceptionally comprehensive and cross-cutting effort is required in order for society to effectively manage the situation. The National Risk Profile thus provides a common frame of reference for acute risks of broad societal relevance, and can form part of the foundation for emergency management planning within the national crisis management system as well as in and many other contexts. In some instances it can even serve as the starting point for a further planning process regarding more specific circumstances. The risk profile cannot, however, stand alone. Rather, it needs to be challenged and considered in the context in which the readers find themselves.

At the same time, it is important to remember that risks change over time. In this edition, we have chosen to expand the risk profile by adding four trends that may affect emergency management in the slightly longer term. In this way, the National Risk Profile draws up the risk landscape in Denmark both now and in the coming years. First and foremost, it should be seen as an invitation to plan, collaborate, and share knowledge when it comes to our society's emergency management capacities. This way, the National Risk Profile will help promote a solid emergency management culture in Denmark.

I hope you will both enjoy and make good use of this document.

Henning Thiesen
Director General, Danish Emergency
Management Agency (DEMA)

INTRODUCTION

Objectives

DEMA continuously seeks to keep abreast of, highlight and disseminate knowledge about the risks that may lead to major accidents and disasters in Denmark. This work involves gathering information that can tell us about the characteristics and causal connections of individual risks, the current overall state of the risk picture, and how this risk picture may develop in the future.

Some risks are relatively easy to identify and monitor as they regularly manifest themselves as incidents or are generally the subject of great attention. In other cases, a certain amount of imagination is required to detect new risks, or new ways in which familiar risks may develop. The National Risk Profile (NRP) is a periodic summary of the continuous work being conducted to map and analyse the risks that society is facing.

The NRP does not, however, represent the entire spectrum of risks faced by Danish society or the citizens of Denmark. Rather, it concentrates on those risks considered by DEMA to merit the most attention from society's emergency management actors.

The publication has several objectives. First and foremost, it helps create awareness of acknowledged risks and our knowledge about them. As any assessment of risk is dependent on context, the NRP also seeks to give readers the chance to reflect on risks, both those discussed and others, as seen from their own point of view. The NRP may also inspire larger organisations, whether in the private or the public sector, to draw up a risk profile of their own. It can also be used as a reference point for work done by such organisations on crisis management, security, and preparedness. For example, this could be in con-junction with the drafting of emergency manage-ment plans or as inspiration for exercise planning.

In addition to the objectives of the publication listed above, the NRP also meets the requirement of the European Civil Protection Mechanism (EU Council Decision No. 1313/2013/EU of 17 December 2013), stating that member states must develop risk assessments at national or appropriate subnational level'.

Central Concepts

This edition of the NRP consists of two main parts. The first part contains 13 chapters, each of which describes one incident type. The order in which these are presented does not imply any form of ranking. The incident types differ in essence and it is not, therefore, possible to list them in any meaningful order of priority. It will, however, be possible to compare them against each other based on a range of parameters presented in each chapter.

The other main part contains four trends, which in the longer term could prove to have an impact on the risk profile for Denmark. These trends are not ranked in any order, nor is it implied that the list is an exhaustive one. The trends serve to identify some of the sources of change to the risk profile over the coming years.

What is Risk?

The term 'risk' is used in many contexts, often with various intended meanings. In colloquial language, it is sometimes used synonymously with either 'likelihood' or 'consequence'. In other connections – for example, when talking about economy, markets or gambling – risk is combined as a product of likelihood multiplied by consequence: ($R = L \times C$). This formula reduces the two elements of risk to a single, alluringly clear value. However, a precondition for combining the two elements in a meaningful way is that there must be a certain degree of comparability across the range of risks being depicted. This applies to comparability in terms of the information on which we base the likelihood of something happening (e.g. statistical data over time, evidence, or causal understanding), as well as to the comparability/ proportionality of the consequences to which a given incident is expected to lead. This is because our tolerance towards different types of negative impact varies significantly.

Multiplying likelihood by consequence also assumes that we take an equal interest in both the likelihood and the consequence of a given incident. This is typically not the case when we are dealing with major accidents and disasters. An attempt – despite this – to combine likelihood and consequence into an overall, comparable risk value for each incident type would therefore, at best, be a simplification. At worst, it would be grossly misleading.

Nevertheless, 'risk' is indeed made up of likelihood and consequences. In the light of the above, however, these two elements will be addressed separately throughout this publication. Each chapter will aim to provide a qualitative description of our knowledge and our knowledge base as far as both likelihood and consequence is concerned. The NRP thus provides support to further risk assessments relating to a more specific location, context, organisation or event. This intended use is also part of the reason why the incident types described are not ranked by any single parameter.

What is an Incident Type?

In the context of the NRP, an 'incident' means a delimited sequence of events that has significant and immediate negative consequences for society, and requires an acute need for coordination and crisis management within Denmark's borders at a level that is not purely local. Incidents that are manageable within the framework of daily emergency management efforts, as well as incidents of a global nature developing over a protracted period of time, are not included.

'Incident type' is an umbrella term covering incidents that share a sufficient number of characteristics in terms of how they arise and/or what is required of us as a society in order to deal with them. In other words, an incident type is not a scenario, as the incident types described could manifest themselves in any number of specific ways, and at various specific times and places. Dealing with risks in the form of incident types helps us group together central challenge themes, and better understand the components of the known risks that we face. This is part of the merit

in approaching risk through incident types, rather than specific scenarios.

The world that we face, however, is 'muddled and mixed up' and does not always lend itself to categorisation. It is important to remember that incidents carrying traits from several of the incident types presented may also well occur. Evidently, incidents combining negative aspects of several incident types will challenge society's overall capacity for emergency management to an even greater extent.

The incident types are described with a 0–5 year time frame in mind.

What is a Trend?

Further to the incident types, the NRP will also address phenomena that do not meet DEMA's criteria for incident types. These phenomena, or 'trends', are more difficult to define, and their significance less certain than in the case of the incident types. They also typically develop over a longer period of time. The chapters dealing with trends address some of the change processes that may become of major significance to society's emergency management or risk level. For our purpose, a 'trend' is a broad development within a given subject area that could either lead to the occurrence of new incident types, affect how existing ones unfold, or how they are handled. Thus, trends can come to have a major impact on the vulnerabilities within our society, or on our overall capacity for emergency management and the organisational configuration behind this.

The trends are described with a 5–15 year time frame in mind.

Process

The NRP should be seen as a summary of the broad spectrum of work being done in society with regard to risk assessment and emergency management. This work is being done not only by the emergency management players but also by a wide range of authorities with responsibility for specific sectors. Accordingly, the risk profile has been produced with the involvement of experts and authorities. Having said that, it must be

stressed that DEMA alone is responsible for the descriptions, assessments, and summaries contained in the publication.

This publication is a continuation of the work conducted in connection with the preparation of the first edition of the NRP in 2013.

Selection
Initially, all conceivable incident types within the boundaries of the definition above were placed on a gross list. Incident types that are unlikely to occur in or close to Denmark – for example, major earthquakes – were not included, even if such incidents could have consequences for Danes or Danish interests abroad. In the same way, only risks possible in Denmark itself were included, and not those that apply exclusively to other parts of the Danish Realm. Given the considerable differences in climatic conditions, demography, geography, etc., it is more appropriate to draw up separate risk profiles for the Faroe Islands and Greenland. The gross list was then structured giving equal taxonomic value to each incident type. Phenomena that are pure consequences (e.g. power cuts) were included among the consequences of other incident types, and phenomena with significant mutual similarities in terms of how they are dealt with, were grouped together. For example, various types of infectious diseases were grouped together under the inci-dent type heading 'highly virulent diseases'.

Following research and discussions with experts, the incident types on the gross list were reviewed and assessed on the basis of their relevance, with particular emphasis on the impact of their consequences in Denmark in terms of life, health, environment, economy, property, and vital societal functions. The term 'vital societal functions' refers here to the activities, goods, and services that form the basis of society's overall ability to function.

A total of 13 incident types remained, which formed a net list.

A consultation process followed from April to September 2016 involving experts and responsible authorities, during which DEMA

prepared the individual chapters on each incident type.

The selection of trends was done on the basis of what DEMA considered may become particularly relevant to the risk profile. The criteria for inclusion were that, within the next 15 years, each trend should be considered:

- capable of exacerbating the consequences of one or more of the 13 incident types;
- capable of forming the basis of new incident types;
- able to affect the configuration or scope of society's emergency management capabilities;

  or

- able to occupy emergency management resources to such an extent that it would compromise the effective management of other simultaneous incidents.

More trends than the four selected may be said to meet these criteria – for example, the increasing use of drones or the 'Internet of things' (IoT). As we are dealing with a longer perspective for the future, it is not possible to identify precisely which topics will become most pressing.

Nevertheless, the trends provide an opportunity to reflect on how new and old risks will be affected by future developments. Climate change, for instance, is not included as a trend here, as this phenomenon is already having a very real influence on a number of incident types in the risk profile.

Structure
The first part of the risk profile consists of one chapter for each of the selected incident types. Each chapter begins with a brief summary of a relevant serious incident that has taken place in recent memory, in or outside Denmark. The aim here is to provide a concrete image of what the incident type in question may result in when things turn bad.

This is then followed by a description of the characteristics of the phenomena covered by the incident type and the key knowledge about them.

The 'characteristics' section also includes central terms and definitions that require clarification in this context.

Next, the risk outline for the given incident type is expressed in two parts:

Occurrence and consequences. 'Occurrence' describes the basis of the data and experience available to us in terms of assessing under what circumstances (where, why, how often, and when) an incident type may occur. As with anything relating to the future, this is subject to varying degrees of uncertainty. There are great differences in what type of knowledge we have of the individual incident types, how certain this knowledge is, and how we can use it. ' Consequences' describes the immediate damage and loss, cascading effects, and subsequent effects that may arise if an incident occurs. What is meant in this context is loss of human life, injury to human health, negative effects on the environment, society's economy (including the functionality of financial systems and public costs), private/public property, and vital societal functions. These parameters are discussed to the extent that is relevant for the incident type in question.

The risk profile is not an attempt to predict whether, where, when, how often, why, or exactly how an incident will unfold. By definition, extraordinary incidents and the courses they take are impossible to predict with such precision, and the specific course of events will almost always include surprising elements. For the same reason, great emphasis is placed in the NRP on the qualitatively descriptive approach.

As an alternative to creating scenarios involving fictitious courses of events, the 'examples' section describes a selection of previous incidents of relevance to the risks described. The future cannot be predicted on the basis of the past, but experience from previous incidents can provide 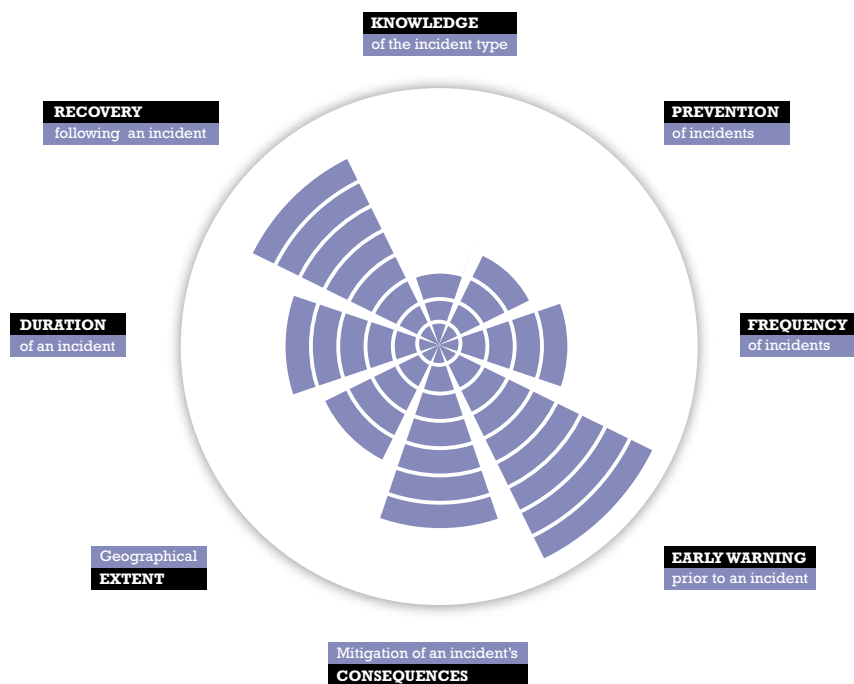important learning points and good insight into possible consequences of future incidents. The examples selected do not constitute a full chronological list and are included by consideration of their relevance to the incident type in question in a Danish context. Examples are taken from Denmark, as well as from other countries in as far as they are comparable to a Danish setting regarding the incident type in question. A number of the examples have themselves propelled new preventive measures and will therefore hardly reappear in the same form entirely. Nonetheless, they serve to illustrate what has previously provoked surprise and resulted in serious consequences.

For the vast majority of incident types, their effective management involves a number of jurisdictions and – in some cases – private actors. In order to provide an overview of organisations particularly involved in the handling of an incident type, these are listed under the heading 'key actors'. This list should neither be considered exhaustive nor in any ranked order. Which players are given a particularly important role in terms of a particular incident will depend on the specific course of events. The list refers to the relevant players at general level. For example, the term 'municipalities' covers a wide range of subordinate units providing various services, such as municipal emergency services, municipal water supply, care of the elderly, etc.

To encourage further reflection, each individual chapter ends by depicting a short fictitious scenario under the heading 'What if...?'.

Accompanying the text in each chapter on the incident types is a figure entitled challenge pattern. For each individual incident type, there are certain aspects that make it particularly difficult for society to deal with. The challenge pattern indicates, for each incident type, the extent to which the following eight parameters represent a challenge to its effective management.:

- KNOWLEDGE about the incident type:
  To what extent is the management of the incident type challenged by the fact that we lack familiarity with, or knowledge about, the characteristics, origin, causal connections or development of the incidents?

- PREVENTION of incidents:
  To what extent is it difficult to prevent the triggering phenomenon underlying an incident from arising?

- FREQUENCY of incidents:
  Do incidents of this type occur often, and to what extent does this in itself constitute a problem?

- EARLY WARNING prior to an incident:
  To what extent does the lack of opportunities for warning the population prior to an incident occurring constitute a problem when managing the incident type?

- MITIGATION of an incident's consequences:
  To what extent is it difficult to prevent serious consequences arising from the incident once it has occurred?

- Geographical EXTENT:
  How big a part of the country can incidents of this type affect at the same time, and to what extent does this make managing them more difficult?

- DURATION of an incident:
  For how long can an incident of this type last, and does the duration in itself constitute a problem?

- RECOVERY following an incident:
  How demanding can it be in terms of time and resources to return to an acceptable normal state of affairs following an incident of this type?

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Illustrative example of a challenge pattern

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The further the shading extends towards the periphery, the greater the challenges associated with the parameter in question.

The individual parameters are indicated relative to each other. Thus, while their relative proportions can be compared across the incident types, the cumulative total quantities cannot.

The challenge pattern is an expression of a qualitative evaluation and draws a characteristic 'fingerprint' of the incident.

Each incident type is also illustrated using a consequence pattern. This illustrates in graphical format the consequences that incidents of this type may have, divided into six parameters: life, health, environment, economy, property and vital societal functions. The consequence pattern helps to provide a quick overview showing which consequence parameters are primarily exposed in the context of this incident type. The most significant parameters are also discussed in the accompanying text under the 'consequences' heading. In this way, the consequence pattern complements this section of the risk outline.

Hazard potential:

- Life
- Health
- Environment
- Economy
- Property
- Vital societal functions

Illustrative example of a consequence pattern

The extent of the consequences is shown from left (low) to right (high).
As we are dealing with incident types that can be expected to develop in numerous different ways, the indication covers a span of possible outcomes or courses of events.
The indicators therefore fade out over a range and do not have a sharply defined end point.
The consequence pattern thus indicates an order of magnitude rather than a specific value.

The indications express a qualitative assessment of the worst imaginable (yet realistic) scenarios.

Relative Comparison

By way of a summary of the first part, all incident types are juxtaposed in an overview. The incident types are listed in the order in which they appear in the publication and no rank order implied. Based on the overall information presented in the preceding chapters, the 13 incident types are assessed in terms of their overall challenges and consequences. With the relative juxtaposition, too, the indications are an expression of an assessment of the worst imaginable (yet realistic) outcomes of a given incident type.

PART ONE:

INCIDENT TYPES

1.

Hurricanes
and Strong Storms

Waves from the storm 'Helga' overrun a pier at Nørre Vorupør in December 2015. Image: Colourbox

The winter of 1999
Seven dead, more than 800 injured and requiring medical attention, and material damages at an estimated total of DKK 13 billion. With an average wind speed of around 40 m/s and gusts of up to 50 m/s, the hurricane of 3–4 December 1999 had a devastating effect on everything in its path.

Almost four million cubic metres of timber were lost to windfall in forest areas, and at the Lindø shipyard near Odense a 114 metre high portal crane collapsed onto a container ship that was in dock. Around 400,000 households were without power for various periods of time.

Characteristics

'Hurricane' and 'storm' are terms used for low pressure systems that form in the atmosphere and result in strong winds at the Earth's surface. When the average wind speed exceeds 33 metres per second (m/s), the event is defined as a 'hurricane'. A low pressure system with wind speeds of 25–33 m/s is categorised as a 'storm'. Although gusts of hurricane strength may occur during a powerful storm, this does not mean that the storm is defined as a hurricane. Whatever the category, therefore, individual gusts can have the same destructive potential whether occurring during a storm or during a hurricane.

At Danish latitudes, intense low pressure systems develop in areas where the atmosphere is dominated by major temperature differentials – for example, where cold northerly air meets warm air from the south. Where the cold and warm air masses collide, a front is formed. A disturbance (rotation) on the front can lead to the development of an area of low pressure, and this can rapidly intensify to form a large, cohesive, rotating system of winds around the low pressure area.

The greater the differences in temperature between the cold and the warm air, the more intense the development of low pressure and resulting wind strengths. The hurricanes and strong storms that affect Denmark generally arise along the polar front and typically last for up to two days.

Risk Outline

Occurrence

Statistical data on hurricanes and storms in Denmark go back to 1873. From this we know that the conditions for hurricanes and storms over Denmark are most often present during autumn and winter. Between 1950 and 2015, the Danish Meteorological Institute (DMI) recorded 45 storms and hurricanes that affected the country, of which 44 occurred in the autumn and winter months (the period from September to February).

Hurricanes and strong storms can, however, occur at any time of the year. Whatever the time of year, there is a good chance of predicting the development of extreme low pressure systems with a certain degree of precision. This precision increases as new weather models and supercomputers are developed. Although storms and hurricanes rarely arrive without warning, it is still difficult to accurately predict their path and intensity. Over the past 100 years or so, actual hurricanes have only been recorded on five occasions in Denmark. There has, however, been no shortage of strong storms with average wind speeds close to 33 m/s and destructive gusts of hurricane strength.

Generally, therefore, it can be said that damaging winds are of frequent occurrence in Denmark.

The geographical extent of hurricanes and strong storms can be large enough that the entire country is affected at the same time. As the intensity varies, however, and there can be significant local differences.

Cases have been recorded in Denmark in which two storm-like incidents occurred in quick succession. It is thus not improbable that such incidents could occur mere days or weeks apart.

Consequences

Hurricanes and strong storms arise under a variety of conditions. Still, events often follow a similar pattern. Incidents will last for a limited period of time and are highly likely to have an impact on the same vital societal functions and sectors.

In general, the colder (and therefore heavier) the air, the greater its potential to cause major destruction. Hurricanes and strong storms can cause injury and death from flying objects, falling trees, falling roof tiles and traffic accidents. Simply being or moving around outdoors during and immediately after hurricanes and strong storms can imply danger to life and health. People and animals can also be killed, injured or trapped indoors when weak structures collapse.

Derived consequences to life, health and welfare may also arise if access to urgent police, fire and rescue, medical or municipal home care services is affected as a result of impassable roads and/or partial breakdowns of other infrastructure.

Often nature and rural areas will suffer extensive damage, with entire areas of forest affected by windfall damage. Significant financial losses may incur due to the extent of the damage and the subsequent cost of clearance, restoration, and replanting.

Hurricanes and strong storms typically have a severe impact on the transport sector, as bridges, airports, and ferry routes often must close, and important roads and railway lines can become blocked. On land, transport services often have to be cancelled due to the risk of flying and falling objects etc., while at sea the wind can generate very high waves that pose a danger to maritime traffic.

Hurricanes and strong storms cause significant material damage, both as a direct consequence of the wind and, indirectly, from flying or falling objects. A study by the Danish Insurance Association from 2012 showed that around one in ten Danish homeowners had sustained storm damage in the previous five years. Total losses, where entire roofs and/or outer walls collapse, are not uncommon.

Challenge Pattern:

Hurricanes and Strong Storms

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES
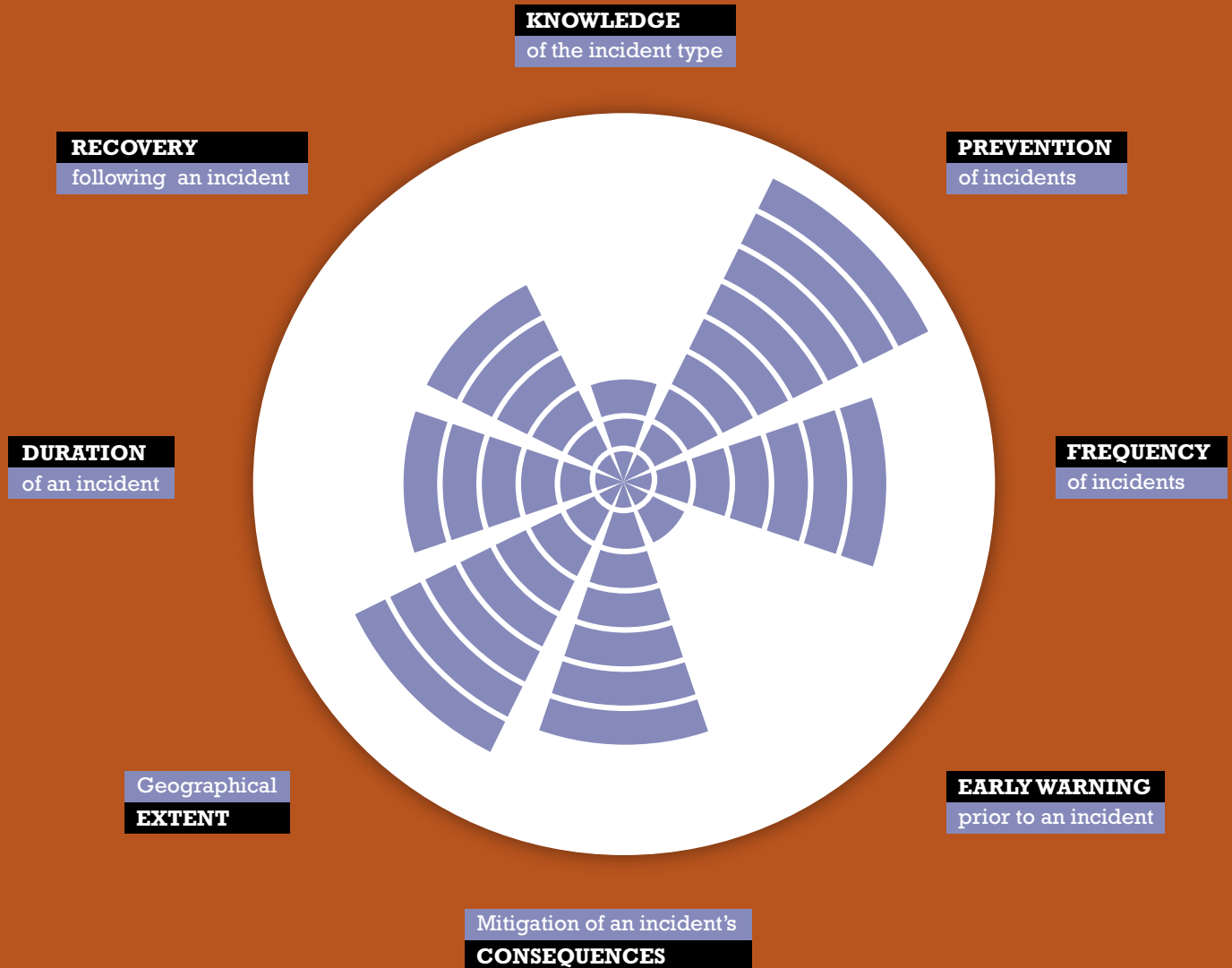
Hurricanes and strong storms occur frequently and often affect the whole of Denmark or large parts of the country at the same time. They cannot be prevented, but it is possible to issue warnings well in advance before an incident occurs. We also have a good understanding of the consequences of hurricanes and strong storms and of the need for recovery that may ensue.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Strong winds can also lead to power cuts, and sustained power cuts can have widespread and serious consequences in a number of ways. However, the risk of extensive power failures due to collapsed electricity pylons has been significantly reduced over the past decade, during which most of the low voltage grid has been laid underground.

Finally, IT and telecommunications services can also become overloaded by an extraordinary number of simultaneous users and therefore disrupted. This can result in derived consequences for a wide range of other vital societal functions.

Examples

The first hurricane of the 20th century in Denmark occurred on 25–26 December 1902 and led to major destruction. The next hurricane occurred on 23–24 October 1921 and is often referred to as the 'Ulvsund hurricane', named after the steamship Ulvsund that was wrecked in the Øresund strait between Denmark and Sweden with the loss of 17 lives on board. It was not until 46 years later, in October 1967, that Denmark was again hit by a hurricane.

On 24–26 November 1981, Denmark experienced a hurricane along the west coast of Jutland and in North Zealand. This was unusually longlasting by Danish standards and therefore caused greater destruction and windfall damage, as well as prolonged closures of roads, railways and ferry services. In the North Sea one fisherman died. The total cost of the hurricane was estimated to have approached DKK 900 million.

The hurricane of 3–4 December 1999 affected the entire country and, with the exception of North Jutland, gusts in most places reached 40–50 m/s. The hurricane necessitated an extensive emergency management effort.

On 8 January 2005, the country was hit by a particularly strong storm, with hurricane force gusts and average wind speeds of hurricane force locally in the northern and western parts of the country. The storm cost the lives of four people: two people died when they were hit by a roof that had been torn loose, and two people lost their lives when their vehicles were hit by falling trees. There was a serious impact on traffic in large parts of the country, with bridges closed and trains, buses, Metro services, and flights cancelled. As a result, it is estimated that around 4,000 people were left stranded at bus stops and railway stations, and there were also examples of people being forced outside into the dangerous weather conditions as shops and department stores closed their doors at the same time as the public transport system was closing down. Around 200,000 users were affected by power cuts of varying duration; however, this was fewer than during the 1999 hurricane, due in part to the fact that an extensive cable-laying exercise of the low voltage network had taken place in the meantime.

Several telephone exchanges and large parts of the mobile phone network were also out of service for a time. In the forests, over two million cubic metres of wood were blown down. The total damage was estimated at around DKK 4 billion.

On 28 October 2013, Denmark was hit by a violent storm with gusts of unprecedented strength. The storm – named 'Allan' – resulted in major damage to property and infrastructure. The highest average wind speed for 'Allan' was measured at 39.5 m/s at Røsnæs lighthouse, with gusts as high as 53.5 m/s (193 km/h) at Kegnæs lighthouse – a Danish record. 'Allan' mainly affected South Jutland, Funen and Zealand. Three people died as a result of flying roof components and a collision with a fallen tree.

Less than five weeks later, on 5–6 December 2013, Storm 'Bodil' struck, causing not only storm damage but also extensive flooding in some parts of the country that destroyed the homes of over 600 families. The highest average wind speed at Nissum Fjord was measured at 36.6 m/s, with a highest gust of 44.2 m/s. One person died during the storm.

Consequence Pattern:

Hurricanes and Strong Storms

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Key Actors

- **Danish Meteorological Institute**
- **Danish National Police**
- **Danish Emergency Management Agency (DEMA)**
- **Danish Transport, Construction and Housing Authority**

- **Danish Road Directorate**
- **Banedanmark (railway infrastructure company)**
- **Transport operators**
- **Energy supply companies**
- **Municipalities**
- **Danish Storm Council**

Being outdoors during a hurricane or a storm can be dangerous to life and health, e.g. due to falling roof tiles or the collapse of temporary structures. The picture shows a scaffold that collapsed in the centre of Copenhagen during a storm in 2013. Image: SCANPIX

What if…

…an extreme storm were forecasted to hit Northern Germany during winter?

Instead of proceeding as expected – affecting only the southernmost part of Denmark – the storm changes its course and hits the entire country. The storm also rages for significantly longer than initially predicted.

The Internet and power supply in some parts of the country break down because of the storm. At the same time, the power cuts put most private heating systems out of operation. Many members of the public in the affected areas have not planned for this development and leave their homes to buy batteries, blankets, etc. They do this under the assumption that the storm is just a weak extension of the storm over Germany. The authorities are aware of this unwise behaviour, but are unable to contact all members of the public due to the failure of the power grid and telecommunications network.

The situation is now significantly different to the one foreseen by the meteorological forecasts. The fierce conditions may be expected to lead to a number of injuries and possibly deaths among the public…

2.

Coastal Flooding

A house in Roskilde is flooded as a result of the storm surge during Hurricane 'Bodil'. Image: Martin Stendel/DMI

23 November 1981

An extensive low pressure storm slowly passed to the north of Denmark. The entire country experienced gusts of hurricane force. The water level in the Wadden Sea and North Sea rose dramatically, and the Port of Esbjerg saw the highest water level ever recorded in Denmark – 4.22 metres above normal. The port was flooded, and the economic costs, expressed in DKK millions, exceeded a two-figure sum.

The island of Mandø was more or less completely flooded and its 200 sheep drowned, as the island's dykes were badly damaged or destroyed.

Several other dykes along the Wadden Sea coast collapsed under the enormous pressure of the water.

Characteristics

Coastal flooding occurs when the sea level rises enough to suddenly flood urban or rural areas. A number of conditions can cause the water level to rise, such as strong winds and seismic activity.

Powerful winds can push large quantities of sea water inland. If the water level exceeds a locally determined threshold, this phenomenon is referred to as a 'storm surge'. Storm surges are influenced by a number of factors: the direction and strength of the wind, the degree to which the water accumulates in situations involving onshore wind, the shape of the coast, atmospheric pressure, and tides. The most serious storm surges are created in the combined presence of these factors. The direction and strength of the wind affects the water level along the coasts. The water level rises with an onshore wind and falls with an offshore wind. At an average wind speed of 21–25 m/s, which is equivalent to a strong gale, the water level in an onshore wind will frequently rise enough to create a storm surge. Although

wind strength is the most important factor, there have been examples of flooding at low wind strengths as well.

When the wind presses on the water surface, forcing water masses in a given direction towards a coastline, through a narrow strait, or into inner waters, it can have an acummulative effect. This wind-driven accumulation effect has the greatest impact at shallow depths, so the topography of the coastline is also of importance. Low-lying areas such as marshland and fjord areas will more often be subject to coastal flooding due to winds pushing sea water towards land mass.

Atmospheric pressure also has a significant influence on the water level. For each drop in atmospheric pressure by 1 hectopascal (hPa), the water level rises by 1 cm. Standard atmospheric pressure is 1013 hPa, but in stormy weather pressure typically falls to 970–980 hPa, which means a rise in water level of 0.3–0.4 metres.

Tides are principally caused by the gravitational pull of the Moon and Sun. The height of the high tide depends on the position of the Earth relative to both the Sun and the Moon. Certain configurations of the Sun, Moon, and Earth cause the high tide to be higher than average. These are called spring tides and they occur approximately every 14 days. Spring tides have a significant effect on the water level.

As well as air masses being able to push water inland, coastal flooding can also result from flood waves. With certain rare weather systems, a flood wave may arrive more than 24 hours after the wind. Coasts can also be subject to flood waves triggered by seismic activity, such as underwater earthquakes and landslides. These flood waves are called tsunamis. The strength of flood waves depends on the depth of water, and they decline in strength as they move over shallower water. Particularly unfortunate combinations of the above phenomena in Denmark can lead to coastal flooding.

Risk Outline

Occurrence

Denmark lies at an average of only 31 metres above sea level and has approximately 7,300 kilometres of coastline. Many large Danish towns and cities are located right on the coast, making them exposed to coastal flooding. The continuing urban development in zones bordering the coastline creates new vulnerabilities to coastal flooding.

Incidents categorised as storm surges affect Denmark on an almost annual basis. Data from recent years show that there have been some years without storm surges, but also that there have been years with up to four incidents. From 2000 to 2015, a total of 16 floods occurred with a magnitude categorizing them as a storm surge.

The frequency of coastal flooding varies seasonally. Flooding occurs mostly in the winter months, when low pressure systems pass over the country, often bringing strong winds. This can result in everything from minor flooding to storm surges. Locally, areas can be more or less liable to coastal flooding. This depends, among other things, on the erosion of dykes along the coastline and on how great a height difference there is between the coast and the nearby inland areas. In this respect, there is a difference between Denmark's inner and outer waters. The outer waters are the North Sea and the Wadden Sea, while the inner waters cover the area from the Kattegat and down over the eastern part of the country. The entire west coast of Jutland is exposed to hard onshore westerly winds and has large tidal ranges. The Wadden Sea area consists of flat marshland that floods rapidly. Dykes have been built along large parts of the west coast of Jutland in order to protect the towns in South Jutland. In the inner waters, the water level and wave heights cannot reach the same magnitude as those on the west coast of Jutland. However, the areas along the fjords in the Danish inner waters are often less protected against rises in water levels by natural barriers or structural installations,

and therefore more liable to damage from flooding than the West Coast. For example, on several occasions fjord areas on Funen and Zealand, as well as east-facing fjords on Jutland, have been subject to storm surges that have resulted in major flooding.
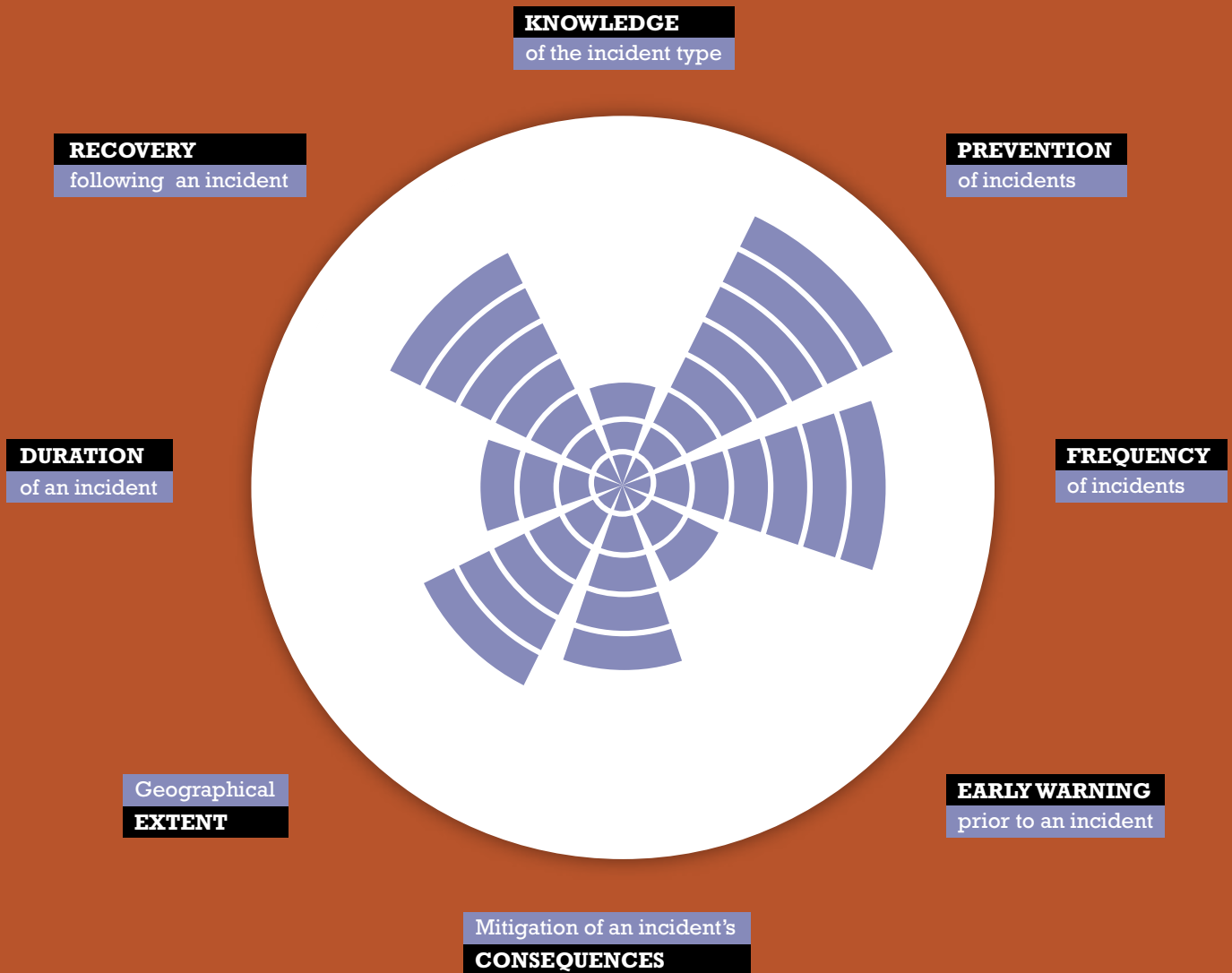Under the EU Floods Directive, Denmark has designated ten risk areas that have a particular risk of flooding. Nine of these areas lie along the coastlines or fjords of inner Danish waters.

The likelihood of a tsunami causing any serious flooding in Denmark is very slight. The distribution and types of seismic zones in the North Atlantic mean that tsunami-triggering seismic activity is extremely rare. Smaller, fastmoving waves could, however, hit the coasts. These could affect both the Danish outer and inner waters.

Climate change will lead to a rise in sea levels, changes to wind patterns, and more frequent occurrences of extreme weather situations. In general, it is expected that situations in which the sea level attains heights well above normal will both occur more often and be more extreme. Projections drawn up by the DMI on the basis of figures from the UN Intergovernmental Panel on Climate Change (IPCC) show that the water level in the seas around Denmark will rise by between 0.1 m and 1.1 m from now until the year 2100. It is estimated that the storm surge water level along the west coast of Jutland will rise by 0.3 m between now and 2100 as a result of changes in weather conditions, including an increase in wind strength.

Denmark experiences a general annual land uplift of between 0.3 mm and 2 mm as a result of isostatic pressure, a movement set in motion following the melting of the ice from the last Ice Age. Locally, however, the value varies considerably. In a number of coastal and urban areas, for instance, the opposite is true, with the land actually subsiding by up to 10 mm per year.

Challenge Pattern:
Coastal Flooding

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Preventing coastal flooding in a low-lying country like Denmark is a difficult and resource-intensive task. Adding to that, the recovery phase following an incident can be both costly and protracted. On the other hand, we have a high degree of knowledge available about the phenomena behind this type of incident, as well as a good chance of limiting the immediate consequences of an incident by issuing early warnings.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Consequences

The damage potential of coastal flooding and its derived consequences is largely determined by structural initiatives such as dykes, and non-structural measures such as legislation, urban planning, and public awareness of flood risk. Dykes have been built or beach nourishment has been performed along most exposed sections of the West Coast. ('Beach nourishment' is obtained by adding sand to the coastline to provide protection.) In the inner Danish waters, there are many areas with flood risk that do not have dykes. Dykes protect against flooding when the water level rises and are therefore essential for safeguarding human lives and property in low-lying areas.

When the water level rises, the water is pushed up against the dykes. With each occurrence of a rise in water levels, the dykes can be subject to erosion. This can make them vulnerable to collapse over time. Dykes can fail even if they are maintained and even if damage caused by erosion is repaired. As long as the dykes do not overflow or break, the impact on human life in particular is limited. Incidents that occurred in the time before dykes were built have involved significant loss of human life – for example, along the West Coast and on the island of Falster. Such incidents may seem remote today, but they illustrate what the failure of a dyke can mean.

As well as the dykes, a specific storm surge preparedness measure has now been set up for both the Wadden Sea and the North Sea. This entails that, following a warning from the DMI, an evacuation procedure can be effectuated rapidly, should it prove necessary. Evacuation may also be necessary elsewhere – for example, near inner waters.

Coastal flooding can have consequences for health if wastewater plants and sewers are inundated. This can expose people to pathogenic (disease-causing) micro-organisms through contaminated water.

Freshwater sources can be inundated with sea water. As sea water is saline, this will cause the freshwater to become saline, with consequences for both animals and plants that require access to freshwater. In this way, major disturbances can occur in local ecosystems. Salt also causes problems to agricultural areas inundated by sea water. Salt impairs osmosis in plants, causing them dehydrate and thus preventing growth. Saline soil cannot, therefore, be used for cultivating crops and will lead to significant financial losses in the agricultural sector.

Coastal flooding can have an impact on the water supply if sources of drinking water are contaminated by salt water. Waterworks may become flooded themselves, and following a flooding sea water can slowly permeate into the groundwater from pools left the terrain. There is no set maximum threshold for the salt content in drinking water, but clearing wells and cleaning water can be a costly matter.

Many areas with flood risk house industrial developments, including some that are classified as 'hazardous facilities'. Flooding here can lead to spillover of chemical substances, which can then spread over wide areas. Apart from this constituting a health risk, cleaning the areas will often be a protracted and costly matter.

The financial consequences of coastal flooding will depend on the areas are affected. If an intensely built up or densely populated area is flooded, the financial consequences and damage to property can often be great. Basements and ground floors of homes and commercial facilities, may be affected by water bodies to such an extent that they cannot be used for long periods while repair work is carried out. In such cases, damage amounting to several millions of Danish kroner may be incurred. The economic costs can be particularly high when flooding affects large parts of the country at the same time. Coastal flooding can also pose problems to infrastructure vital to society. Roads, railway lines close to coastlines, and Metro systems can be temporarily closed due to flooding. Flooded areas can also be affected by power failures, which are associated with a long range of cascading effects.
The worst storm surge in relatively recent times

Consequence Pattern:
Coastal Flooding

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Examples

in the North Sea occurred in February of 1953. Flooding particularly affected the Netherlands, where dykes collapsed, and the United Kingdom, where the Thames burst its banks, leaving many buildings in ruins. The floods led to around 2,000 deaths in the Netherlands and several hundred in the United Kingdom. Following this incident, both countries resolved to initiate huge projects designed to secure their coastlines. These projects took around 40 years to complete.

In February 1962, a storm surge along the North Sea coast of Germany led to a flood wave moving up the Elbe River. Its record height destroyed several dykes and flooded the city of Hamburg. This resulted in 315 deaths, while several thousand people lost their homes. The 1962 storm surge was the most recent North Sea storm surge to have resulted in the loss of human life.

The hurricane that passed Denmark on 3 December 1999 led to a storm surge along the Wadden Sea and North Sea. The gauges on the dykes at Ribe, Esbjerg, and Højer were broke, and even though the measured water level of 5.12 m at Ribe is still a record high, the water level has probably been even higher when the hurricane was at its most intense. The water level reached this height at the time of low tide. Had the water level peaked just six hours later, at high tide, the dyke at Ribe would have probably overflowed.

On 5 December 2013, Storm 'Bodil' hit Denmark. When the storm reached the coastline, the wind veered to the north-west, pushing large volumes of water from the North Atlantic into the Kattegat. There was major flooding in Roskilde Fjord, where the water level was more than two metres above normal. At the same time, there was major flooding and destruction at Holbæk Fjord, Odense Fjord, Isefjord, and in Copenhagen. The incident cost over DKK 900 million in damage payments.

Key Actors

- Danish Coastal Authority
- Danish Meteorological Institute
- Danish Environmental Protection Agency
- Danish National Police

- Danish Emergency Management Agency (DEMA)
- Municipalities
- Danish Storm Council
- Energy supply companies

Flooded roads in Frederikssund after a storm surge in Roskilde Fjord flooded parts of the town. Image: Martin Stendel/DMI

What if…

…a strong storm from the south-west were to rage across the Baltic Sea? Even though the storm lasts for more than two days, it causes only limited flooding.

However, the storm has caused significant volumes of water to build up in the north-eastern Baltic Sea Basin. Once the storm has subsided, the water flows back. The narrow straits of Little Belt and Great Belt restrict the reverse flow of the vast volumes of water, and thus the water level in the southern part of Denmark increases dramatically. Parts of South Denmark, Funen and Zealand, including the area around Køge, are flooded…

3.

Extreme Rainfall

Cloudbursts are local phenomena that arise suddenly. They are impossible to forecast precisely and it is, therefore, very difficult to provide the public with a sufficiently early warning. For this reason, cloudbursts can easily cause traffic problems, such as here in Vesterbro, Copenhagen, during the major cloudburst of 2011. Image: Lisa Risager

Copenhagen 2011
On Saturday 2 July 2011, Greater Copenhagen was hit at short notice by a cloudburst of hitherto unprecedented proportions. Within 24 hours, more rain fell than the normal average fortwo months. This led to massive flash floods and necessitated an extensive and lengthy emergency management effort involving a large number of actors.

By the extent of material damage caused, the cloudburst was the most expensive natural incident to occur in Denmark since the hurricane of 1999. Damage payments in Greater Copenhagen alone were calculated at a total of DKK 6.2 billion, spread over 90,000 insurance claims.

Characteristics

Episodes of extreme rainfall are probably the type of weather event that has affected Danish citizens, homes, businesses, public institutions and critical infrastructures most notably in recent years. 'Extreme rainfall' means that more rain falls than can drain away or be absorbed in the ground over a given period of time. The term covers three different phenomena: cloudbursts, heavy rain, and consecutive rainfall events – each varying in terms of the extent, duration, and intensity of the precipitation.

In meteorological terms and as a criterion for issuing warnings, a 'cloudburst' is defined as a brief, heavy rainstorm where the amount of precipitation locally exceeds 15 mm over 30 minutes within the area to which the warning applies.

'Heavy rain' is defined as precipitation at a rate locally exceeding 24 mm over six hours within the area to which the warning applies.

The development of heavy rain and cloudbursts is affected by many factors in the atmosphere, including the distribution of warm and cold air masses. When the local atmospheric conditions are particularly unstable, cumulonimbus clouds may grow particularly large, leading to heavy rain and/or cloudbursts, often accompanied by lightning, thunder, strong gusts, and hail.

The violent showers caused by cloudbursts are always delimited phenomena, and cloudbursts are typically highly local. Some showers remain stationary over an area, while others drift and spread rain over more and wider areas. Compared with ordinary rain, however, the extent of the affected area is limited. Moreover, the period during which the conditions are right is usually brief. Cloudbursts, in particular, will normally be characterised by an abrupt beginning and end, as well as a rapid and very large fluctuation in the volume and intensity of the rain over a short period and over short distances. It is therefore not possible for meteorologists to forecast precisely when, where, and with what intensity episodes of heavy rain and cloudbursts will occur.
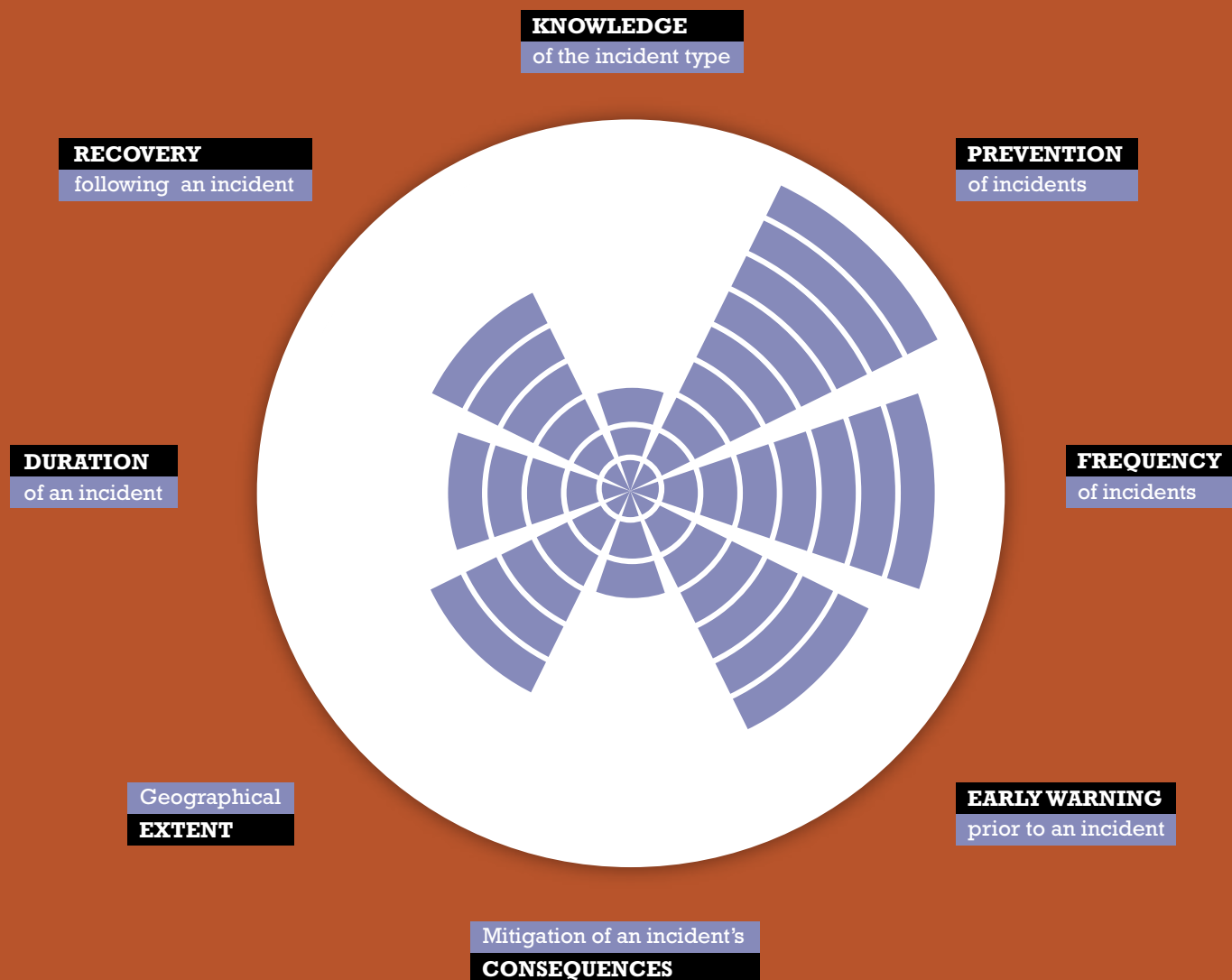
A 'consecutive rainfall event' is created when several rain events occur rapidly after one another. There is no criterion for issuing a warning, as this type of precipitation is not a spontaneous and locally limited phenomenon. Consecutive rainfall events and persistent rain are relatively predictable events for meteorologists

nowadays, as weather radars and weather models are able to provide good forecasts. In the case of consecutive rainfall events, rain fronts trigger each other with short or no gaps in between them, so the volume of precipitation over time can exceed that of both cloudbursts and heavy rain. The ground and the drainage systems (canals, watercourses, lakes, reservoirs, and the groundwater zone) will become saturated with water, and the ground's capacity to soak up water and delay the run-off of the superfluous rainfall will be impaired or disappear completely. Following this, even minor rainfall events may have consequences similar to or exceeding those we normally know from very intense rainfall.

The volume of rainfall in itself as expressed in millimetres is therefore not the sole determining factor when it comes to the extent of the damage caused by a given rainfall event. The volume of rain needs to be seen in combination with other factors, such as the period of time over which it falls and where the precipitation is released, e.g. in terms of ground conditions, topography, density of buildings, and drainage infrastructure.

Challenge Pattern:

Extreme Rainfall

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Extreme rainfall is unavoidable and occurs frequently in Denmark. It is difficult to forecast the time and place of cloudbursts, in particular. In many urban areas measures have been implemented in order to reduce the consequences of extreme rainfall.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Risk Outline

Occurrence

Since 1990, annual rainfall in Denmark has averaged around 745 mm. In the last 150 years or so, rainfall in Denmark has increased by around 25 per cent, with a particular acceleration noted since the 1980s.

An increase in the number of actual cloudbursts is more difficult to document, as it was not until 2011 that the DMI acquired rain gauges that are able to measure the intensity of precipitation. There is therefore only a weak base of data on which to assess whether or not cloudbursts occur more often today than previously. The rain gauges are set up at strategic locations and do not cover the entire country. Furthermore, radar systems have a limited ability to detect cloudbursts. As we are dealing here with an extremely local phenomenon, many cloudbursts are presumably never officially recorded.

Heavy rain, consecutive rainfall events, and cloudbursts can occur anywhere in Denmark. Their development is affected not only by atmospheric conditions but also by the conditions at the Earth's surface. Large cities, in particular, may be more susceptible to heavy rain and cloudbursts than are smaller urban and rural areas. This is due to what is called the 'urban heating effect', which is mainly created by densely packed buildings that bulks up heat from the Sun and blocks the cooling effect of the wind. In calm summer weather, this effect can generate air temperatures above city areas that are several degrees above those of the surrounding countryside.

The conditions favouring cloudbursts are usually present during hot weather, and summertime is therefore the high season for heavy rain and cloudbursts. Showers usually form during the daytime due to the heating effects of the Sun, but they can also form during the night if significant cooling takes place in the cloud tops. Consecutive

rainfall events, by contrast, can occur throughout the year, as the phenomenon is facilitated not by short precipitation events but by several longlasting ones that are not affected by the urban heating effect. The basis for this is most often present during the autumn and winter. These patterns are expected to become clearer as the climate changes.

Most events involving extreme rainfall can be predicted rather accurately by the meteorological services. Moreover, in the spring of 2016 the DMI acquired a new supercomputer that can process larger volumes of data. This offers meteorologists the opportunity to improve the documentation and forecasting of extreme rainfall. However, it will still be difficult to give accurate warnings of the location and intensity of cloudbursts. Thus, cloudburst forecasts will – for the foreseeable future – continue to be more prone to error than other meteorological forecasts.

There is broad agreement among meteorologists and climate researchers that the risk of cloudbursts in Denmark will increase in line with the expected gradual increase in air temperatures as a result of global warming. We can therefore expect changes in rainfall patterns, with summers characterised by lengthy dry spells and a number of intensive precipitation events (cloudbursts and heavy rain) and winters of generally increased, long-lasting rainfall and thus greater potential for consecutive rainfall events.

Consequences

In urban areas, particularly, the direct and derived consequences of extreme rainfall can be widespread and include consequences for health, property and infrastructure. While the possible health consequences of extreme rainfall should not be underestimated, the biggest challenges presented are primarily material damage due to flooding. A distinction is made in this respect between purely hydrological flooding, which occurs in rural areas and has no major impact on

Consequence Pattern:

Extreme Rainfall
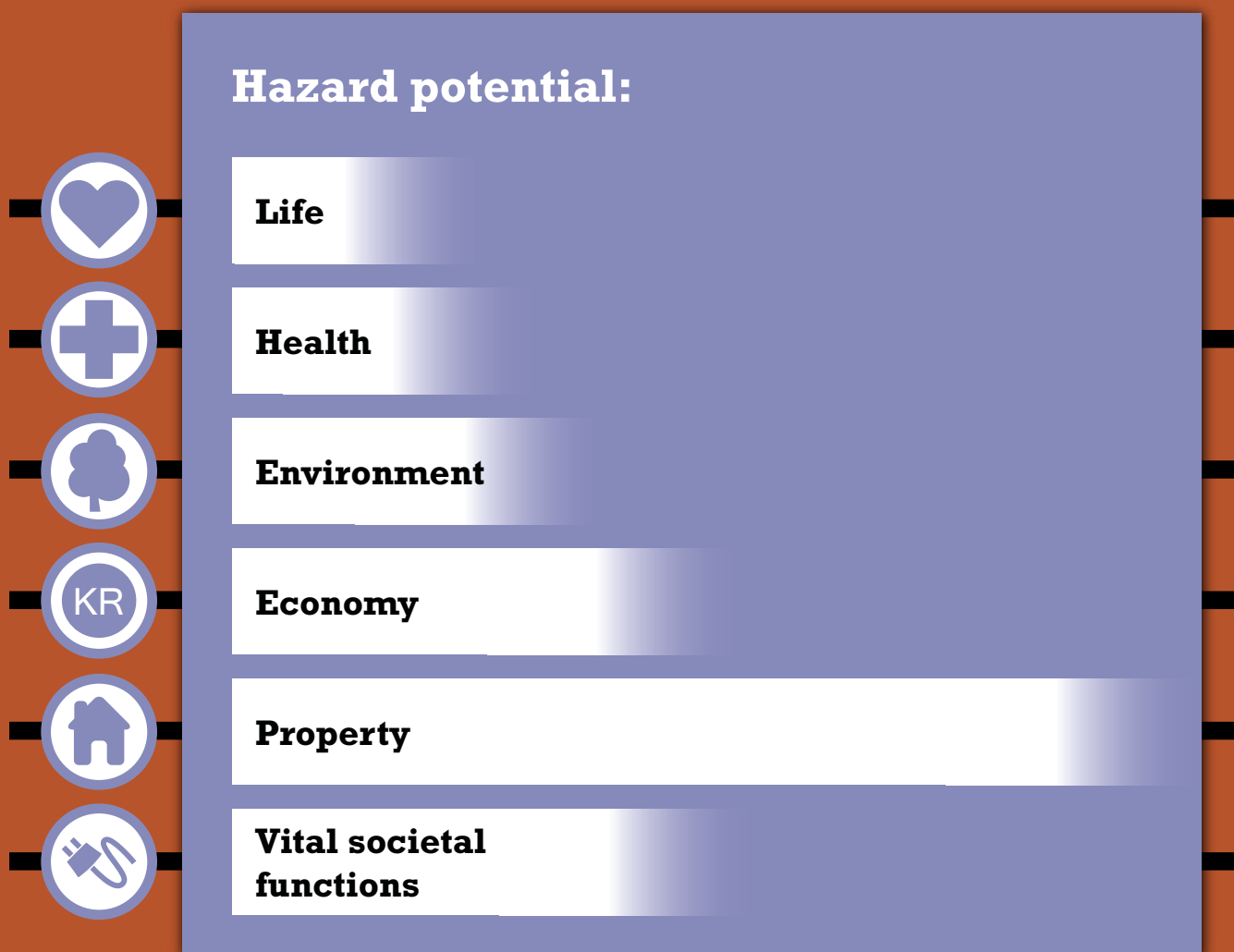
Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

society, and damaging floods that affect populated areas and infrastructure.

Extreme rainfall events can have widespread consequences for property, in particular. The cloudburst in Greater Copenhagen on 2 July 2011 was, according to reinsurance company Swiss Re, the most costly single event in Europe of that year. Based on figures from the last ten years, calculations from the Danish Insurance Association (DIA) show that the total annual compensation payments in Denmark, resulting from damage caused by extreme rainfall, have averaged at around DKK 825 million. However, the total costs are higher than those shown by the insurance payments, due in part to the fact that the Government and many municipalities are fully or partly self-insuring. Furthermore, some losses and damage cannot be replaced or stated in financial terms – for example, archives, museum objects, and other items of cultural heritage damaged by water or moisture. Acute risk of personal injury can arise in traffic junctions affected by cloudbursts as a result of reduced visibility, danger of aquaplaning, or malfunctioning traffic signals at junctions where flooding has led to power failures. Other dangerous situations can arise when people attempt to force their way through deep pools of water or climb onto installations – for example, after having been obliged to leave a car that has suffered engine failure in a flooded underpass.

The water that comes to lie, for example, in basements and streets during flooding is often a mixture of rainwater and sewage water. Human contact with sewage water constitutes a serious hazard to health, even if the water has been diluted in the otherwise clean rainwater. Untreated wastewater may also be diverted into lakes, streams, harbour basins, and the open sea. However, as bacteria die quickly in salt water, and a little slower in freshwater, contamination will typically disappear in a few days.

Extreme rainfall can put pressure on emergency management and have an impact on vital societal functions. For example, flooding can make driving conditions more difficult for emergency vehicles and jeopardise power supplies, emergency power

systems, servers, and other IT equipment critical to the operation of alarm and call centres, hospital departments, etc. Experience also shows that emergency services can come under pressure from call-outs to false alarms from automatic fire alarm systems, which are activated much more frequently during floodings than normally.

Other vital societal functions can also be hit. There is a possibility that flooding may affect accessibility to the road network and lead to road closures lasting for days. Rail traffic operations can be disrupted by flooding of low-lying tracks, cables, points, etc., and by breakdowns of IT systems critical to traffic operation caused by flooding or lightning strikes. Roads, rails, and railway embankments can also be undermined and collapse, leading to a risk of personal injury, long-lasting disruption to traffic, and major repair costs. Due to its deep-lying infrastructure – which includes stations, tunnels, and technical installations – the Copenhagen Metro is at risk of long-lasting disruption to its operations in the event of water damage. However, an increased focus on preventive measures and a continual series of upgrades by infrastructure managers in the road and rail sectors – including the Metro – means that the risk of stoppages due to flooding has been reduced compared to previous. Added to this is a greater emphasis on the protection of infrastructure from the beginning of a project's planning phase.

In the energy sector, flooding and lightning strikes can cause power failures, while flooded steam wells and district heating pipes can lead to a lack of heating and hot water. In the field of IT, servers and other IT equipment – along with associated cooling systems, power relays, and emergency power generators located in basements – may break down due to water and moisture damage, short circuits, and fires. Similarly, telephone exchanges and mobile phone masts can fail due to flooding or lightning strikes.

Examples

The cloudburst of 2 July 2011 over Greater Copenhagen arose at the time of what, from a meteorological point of view, was an unusually explosive development of thundershowers approaching across the Øresund strait. The severity of the incident was not recognised until shortly before the cloudburst hit Copenhagen. Although the DMI had issued several risk reports during the day, it was not possible to give a specific warning until shortly before the incident occurred. The bulk of the rain fell within 90 minutes to two hours and was accompanied by large hailstones and thousands of lightning strikes. The central areas of Copenhagen were hardest hit, with many local measurements exceeding 80 mm. A total of 135.4 mm was measured at the Botanical Garden, the highest recorded reading in Greater Copenhagen for at least 65 years.

It is the extensive breakdown of the infrastructure that merits particular attention, from an emergency management point of view. Around 10,000 households were affected by power cuts of up to 12 hours, while around 50,000 district heating customers were without heating and hot water for up to a week. A number of the busiest motorways were closed for one to three days. Rail traffic was disrupted by, among other things, flooded stations, tracks, and technical installations, lightning strikes on electrical equipment, breakdowns of IT systems, and, in one case, a landslide. Some lines were closed for days and it took a week before operations returned to normal.
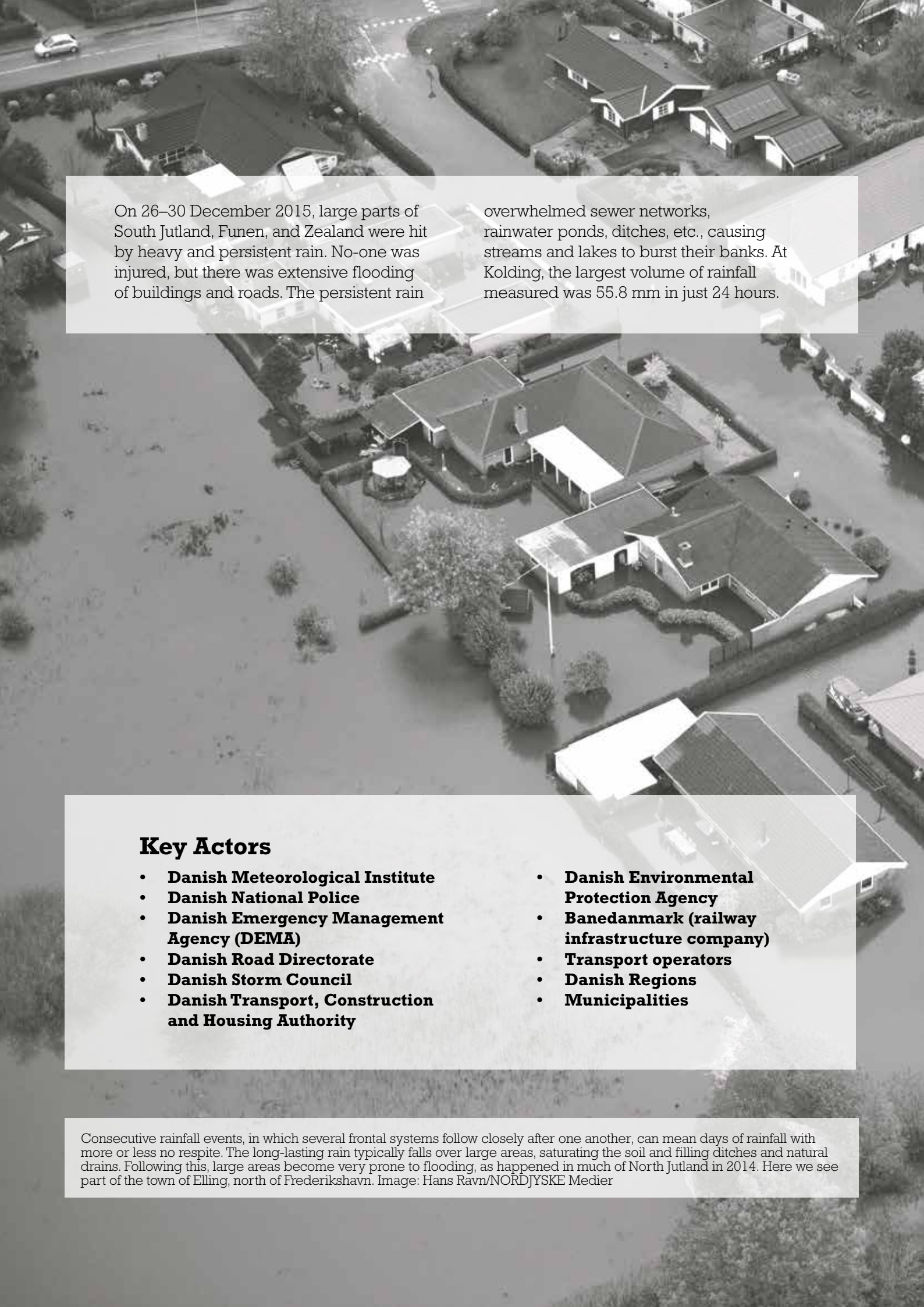
At Banedanmark, flooding of a basement containing technical equipment threatened to bring trains to a halt on railway lines throughout Denmark. Other affected IT and telecommunications systems of importance to society included the DMI's supercomputer and website, the Road Directorate's trafikken.dk, one of TDC's telephone exchanges, the Copenhagen Police's telephone system, Copenhagen Municipality's emergency call system for the city's

elderly citizens, and the IT systems at Vestre Prison.

In total, it is estimated that 70 per cent of Copenhagen Municipality's crosscutting, commercially critical IT systems were close to breaking down. The emergency telephone number 1-1-2 worked, but flooding in the technical room of the Alarm Centre for Greater Copenhagen caused parts of the communications equipment and disposition technology to fail and led to the risk of a system breakdown.

On 15–16 October 2014, large parts of eastern areas of North Jutland were hit by extraordinarily heavy and persistent rain. A total of 148.1 mm fell at the DMI weather station at Lendum over the two days, and in some places over 100 mm of rain fell in a single 24-hour period. No one was injured, but there was extensive flooding to buildings, roads, and railway lines as well as undermining of road culverts and railway embankments. In the Vendsyssel district, particularly around Hjørring and Frederikshavn, the floods were the worst in decades.

During the month of November 2015, almost double the average amount of rain fell in parts of Central and West Jutland (171 mm as opposed to 94 mm). The volume of rain led to high waters in Holstebro but did not cause the town to flood. However, after prolonged rain the ground was saturated to such an extent that the additional 32 mm of rainfall that fell on the hinterland of the Storå river on 5–6 December could not be absorbed. As a result, most of the water flowed into the Storå river, causing massive floods in Holstebro days later.

On 26–30 December 2015, large parts of South Jutland, Funen, and Zealand were hit by heavy and persistent rain. No-one was injured, but there was extensive flooding of buildings and roads. The persistent rain overwhelmed sewer networks, rainwater ponds, ditches, etc., causing streams and lakes to burst their banks. At Kolding, the largest volume of rainfall measured was 55.8 mm in just 24 hours.

Key Actors

- **Danish Meteorological Institute**
- **Danish National Police**
- **Danish Emergency Management Agency (DEMA)**
- **Danish Road Directorate**
- **Danish Storm Council**
- **Danish Transport, Construction and Housing Authority**

- **Danish Environmental Protection Agency**
- **Banedanmark (railway infrastructure company)**
- **Transport operators**
- **Danish Regions**
- **Municipalities**

Consecutive rainfall events, in which several frontal systems follow closely after one another, can mean days of rainfall with more or less no respite. The long-lasting rain typically falls over large areas, saturating the soil and filling ditches and natural drains. Following this, large areas become very prone to flooding, as happened in much of North Jutland in 2014. Here we see part of the town of Elling, north of Frederikshavn. Image: Hans Ravn/NORDJYSKE Medier

What if…

…during one week in January more rain were to fall over Central Jutland than the average for the entire month? The rain falls over a very large area; however, the immediate effect is only a minor, local flooding. Over a few days, the ground in the area becomes saturated. Water can no longer percolate through, instead flowing over the surface of the ground, through drainpipes, and out into streams and lakes. After a day without rain, a more powerful and more local rainstorm occurs in the same area, lasting several hours.

Due to the saturated ground, the artificial lake Tange Sø accumulates so much water that the Tangeværket hydroelectric plant is forced to open its sluice gates to avoid structural damage.

In Randers the warning is out that soon, massive volumes of water from the Gudenå river will flood parts of the city…

4.

Highly Virulent Diseases
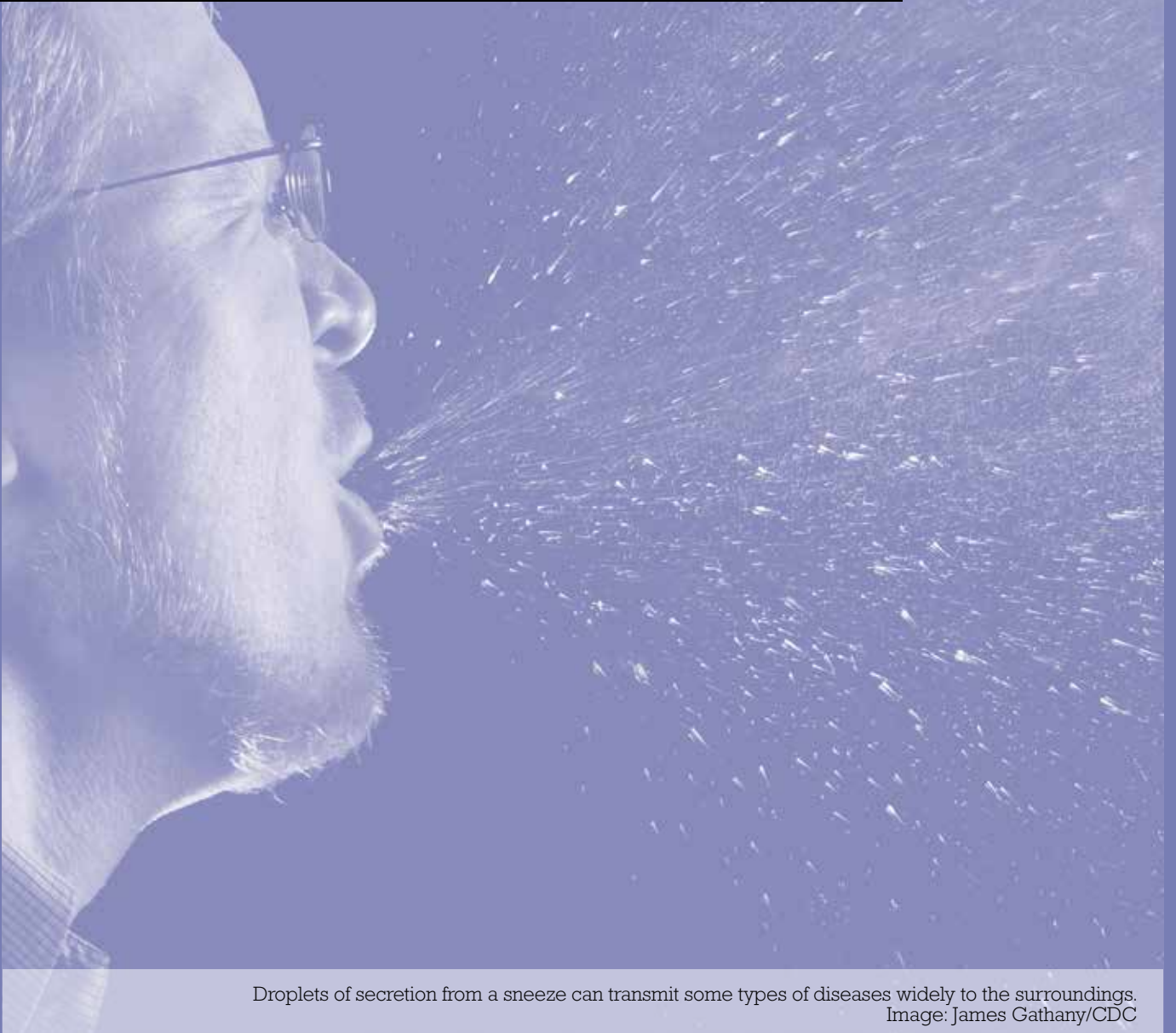
Droplets of secretion from a sneeze can transmit some types of diseases widely to the surroundings.
Image: James Gathany/CDC

In November 2002

…Severe Acute Respiratory Tract Syndrome (more popularly referred to as SARS) began to spread on the Chinese mainland. The airborne virus initially caused a high-grade fever and other flu-like symptoms in those infected, but later also severe pneumonia.

One guest in a hotel in Hong Kong infected 16 others staying on the same floor. These guests then travelled on to Canada, Singapore, Taiwan, and Vietnam – upon which the disease rapidly spread further.

By July 2003, at least 8,096 people in 37 different countries had been infected with SARS. A total of 774 deaths from the disease were recorded, which is equivalent to a mortality rate of almost ten per cent. No major outbreaks of SARS have been seen since 2003.

Characteristics

In this context, the term 'highly virulent diseases' refers to diseases that have the ability to spread easily among a population or to cause serious harm to those infected. An agent that causes disease is called a pathogen – and is most typically a bacterium or a virus. Other examples of pathogens are parasites, fungi, and prions (proteins that are able to propagate within living cells). Pathogens are spread from person to person through the air, through fluids, or by physical contact. In some cases, however, they can also be spread via an intermediate carrier of the

infection (a vector), e.g. mosquitoes or domestic animals.

A pathogen's ability to spread between individuals, and its ability to cause serious symptoms or even death in the infected individual, are two separate aspects of its virulence. One disease may be particularly infectious – in other words, it may spread readily and quickly within a population – but may cause relatively mild symptoms, while another disease may require close and prolonged contact for transmission to

occur, but be deadly once contracted. Both types of disease may be classed as 'highly virulent'. We can divide highly virulent diseases into three categories:

The first category includes well-known diseases that still cause major problems globally but have been completely, or close to completely, eradicated in Denmark. Examples of these are: diphtheria, poliomyelitis, measles, tuberculosis, and cholera.

The second category includes recurring diseases. This includes seasonal influenza (flu), which is caused by various types of flu virus. The seasonal flu virus mutates quickly, with new variations frequently appearing.

As flu viruses are also widespread in animals such as pigs, poultry, and wild birds, there is a risk that various types of flu virus may combine in new ways. This can lead to completely new viruses being formed, with the potential to infect and spread among people, and to which no one will have developed immunity. This can lead to global flu epidemics – socalled pandemic flu. The seriousness of the symptoms caused by the various flu viruses vary, as do the groups within a population that are impacted the most.

Irrespective of whether the new type of virus is particularly virulent or not, a specially adapted vaccine needs to be developed for each type of virus. This means that, although we know a great deal about the recurring diseases, dealing with new types of virus is difficult and resource-intensive.

The third category includes new diseases that appear as epidemics for the first time. It may also be a case of the re-emergence of an old disease that we have not seen for many decades, and that was thus assumed to have been eradicated. Perhaps the pathogen is appearing in an altered form, or perhaps there have been changes in the immunal resistance of the population (or parts of the population) to the pathogen, thus allowing the disease to advance vigorously.

Challenge Pattern:

Highly Virulent Diseases

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES
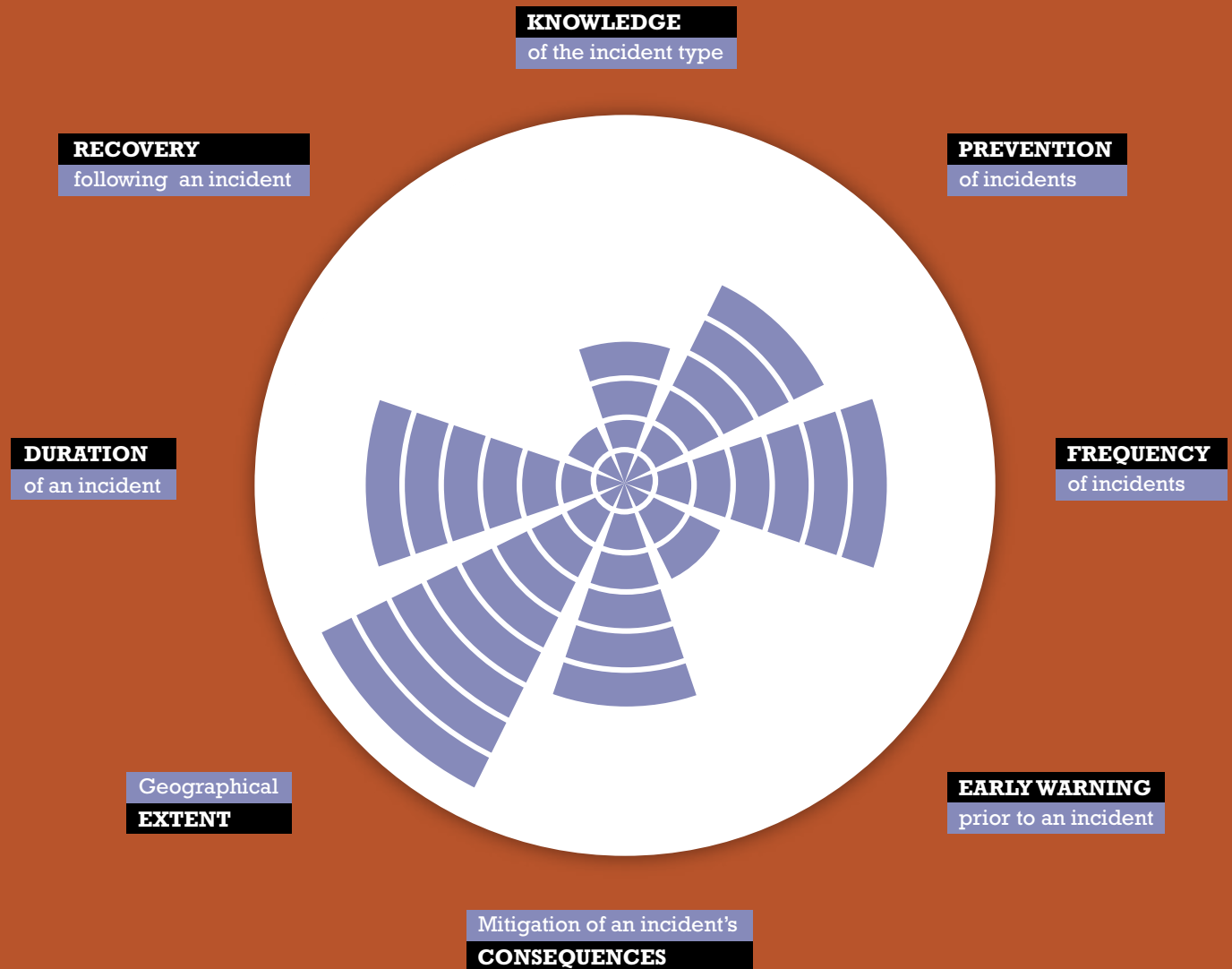
Highly virulent diseases can develop into worldwide pandemics, which are very difficult to fully isolate a popu- lation from. At the same time, an outbreak of disease can last for a very long time before it is brought under control or conquered completely. If we include recurrent seasonal flu, Denmark is affected every year – though with significant variations in terms of the consequences. We generally have a good knowledge about highly virulent diseases, but – due to changes brought about by mutations – new pathogens, carrying new properties, do appear from time to time.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Risk Outline

Occurrence

Diseases with the ability to infect people have always existed. Today, all parts of the world are closely connected and, particularly thanks to international air traffic, people and goods are being widely and quickly transported around the globe. This means that diseases not normally found in Denmark can suddenly appear in the country. Our global interconnectedness also creates the conditions for the rapid spread of pathogens and, thus, the potential for global epidemics – known as pandemics.

Knowledge is the most important single factor in terms of both preventing and fighting pandemics. This of course applies to the knowledge we have about the pathogens themselves (in as far as we are aware of them), but it also applies to general knowledge for example in terms of public health, epidemiology, patterns of disease spread, and hygiene. This knowledge creates a foundation that allows the authorities to inform the public of what they need to be aware of and what the most sensible approach would be to a given disease. The duration and spread of outbreaks of disease depend a great deal on the extent to which people follow the instructions of the health authorities. Typically, this is about the symptoms that people need to be aware of, precautions to be taken in the company of others – at work, school or day care centre, for example – and advice on minimising the spread of infection, such as washing hands or using hand sanitiser.

There are several reasons why the first category of highly virulent diseases does not pose any immediate threat in Denmark. We have a high general standard of hygiene, good living conditions, and an effective health care sector. We also have an effective child vaccination programme in Denmark, which in itself is an important reason why the well-known, highly virulent diseases appear very rarely. There is an overall high level of confidence in the health

authorities among the population, which is very important in terms of ensuring compliance with the recommendations they provide. In the past decade, however, there has been a declining level of participation in some parts of the vaccination programme. Even minor falls in participation can reduce the so-called 'herd immunity', reintroducing vulnerability to highly virulent diseases that are otherwise not prevalent in Denmark.

Within any given population, there will always be individuals that are either too young, or too weak, to be vaccinated against a given disease. 'Herd immunity' is a term that describes how these otherwise vulnerable people will still be protected against that disease due to the fact that it is unable to thrive among the large majority of the population that is immunised. Lack of participation in vaccination programmes can therefore compromise the control we currently have over otherwise well-known highly virulent diseases, which could then break out again, causing great harm. This is why, in the western world, we have seen a number of cases of death and serious complications in small children due to infection with, for example, measles or whooping cough from unvaccinated people.

The second category – recurring highly virulent diseases – primarily consists of various types of flu virus. We are not entirely certain of the causal connection, but the majority of flu cases always occur during the winter months. As the seasons are the opposite in the northern and southern hemispheres, the flu season in countries far south of the Equator falls during the Danish summer months. Here, the virus can mutate into new types, changing its properties by the time it returns to the northern countries.

This seasonal movement of flu is monitored closely in Denmark as well as by the EU and the World Health Organisation (WHO), and to a certain extent it is possible to steal a march on new variants of the virus by developing a vaccine. However, the vaccine developed in advance of the coming flu season is produced on the basis of assumptions about the properties of the new

virus that is about to circulate. As such, it does not always provide full protection. Each winter, the incidence of flu rises in periods of 6–10 weeks' duration, with typically 5–10 per cent of the Danish population becoming infected. Statistically, about every four years a seasonal flu is seen to infect up to approximately 20 per cent of the population, however.

From time to time, entirely new forms of flu virus arise to which no one has any immunity. These can spread globally, regardless of the season, and lead to a pandemic. Historically speaking, pandemic flu has occurred three or four times each century. Flu pandemics can occur in two or three waves, where the second wave is usually significantly worse than the first one.

Some types of flu are found primarily in animals, such as pigs or birds, but can – in rare cases – infect people. We are particularly familiar with this from Asia, where a number of avian (bird) flu viruses have caused serious disease in people. A particular feature of avian flu is that it can easily travel large distances via migrating wild birds, which can then spread the pathogen among stocks of poultry that come into closer contact with people. Entirely new diseases also appear at regular intervals. This is mainly due to the general and constant mutation of existing microorganisms, which sometimes develop particularly virulent strains. The occurrence of virulent new diseases (or the return of old ones after a long absence) may also be linked to changes in the composition of the population, behavioural changes, land use, food sources, the use of pesticides and antibiotics, contact with animals, etc. These factors may both weaken our resistance and expose us to new pathogens. An example of this is coronavirus (CoV), which caused the SARS pandemic in 2002–03. It is thought that the consumption of infected meat from civets (a mongoose-like animal) in China provided the route for the virus to jump from animal to human. Presumably, that particular variant of coronavirus has since been eradicated, but since 2012 another variant of the pathogen (MERS-CoV) has been observed in the Middle East.

Changes in climate conditions can have an effect on the lives of insects and the seasonal migration patterns of larger animals, which can mean that some vector-borne diseases spread to areas in which they were previously unknown. A vector is a carrier of infection that transmits a pathogen from one living organism to another – to a person, for example. Examples of vectors include mosquitoes, lice, and ticks.

In Denmark, we have easy access to medical help. In terms of the preparedness of our health care services, there is generally every possibility of making a clinical diagnosis (where a doctor assesses a patient's symptoms) or laboratory diagnosis (where a pathogen is identified in a laboratory on the basis of tests performed), and to isolate patients (with a view to treatment, observation, and minimising the spread of infection). These conditions are central to dealing with new diseases. Highly lethal (but not very contagious) haemorrhagic fevers such as those caused by the Ebola and Marburg viruses have not occurred in Denmark. Should individual cases occur following travel from other parts of the world, they are not likely to spread widely precisely because of the conditions that we have available for diagnosis and treatment.

Consequences

Highly virulent diseases have direct consequences for the life and health of those affected. The nature of the disease in question determines which group in a population is infected in particular, the mortality rate, and the overall prevalence of the disease. Typically, the main symptoms of flu last for less than a week, followed by one to two weeks of coughing, fatigue, and impaired physical capacity. It may, however, take a more protracted and serious course if the viral infection directly attacks the lungs or paves the way for a bacterial infection. The most serious complication is bacterial pneumonia. Every year, an average of around 1,000–2,000 people in Denmark die from the complications of flu. This excess mortality occurs mainly among weak patients and the elderly, although there can also be a significant disease burden among children and young adults, as these – unlike older people – have not built up immunity through previous exposure to similar pathogens.

Consequence Pattern:

Highly Virulent Diseases

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

A newly emerged disease could well be of a nature that makes it different to, and more virulent than, normal flu. This applies both to the degree of severity of the symptoms/mortality and the prevalence of the disease. Diseases that are contagious before carriers themselves show symptoms can be particularly difficult to control.

A serious pandemic could put the entire health care sector under significant stress, due to the expected dramatic rise in GP consultations, home visits, hospital admissions, intensive care treatment, etc. A large number of those infected – the ones who experience actual complications – will require treatment, and still more people can be expected to seek help because of fears of having developed serious complications. At the same time, health care personnel are also at risk of infection, thereby reducing the capacity of health care services.

There would be an increase in absences from all types of workplaces, with many employees being ill themselves and many others remaining at home to look after sick family members. Derived consequences of this include socioeconomic losses and, in extreme cases, it may challenge our ability to sustain activities that form the basis of society's ability to function. As well as disease and production losses, a pandemic can create anxiety and a sense of insecurity, with attendant consequences irrespective of whether people are infected or not.

Examples

Arguably, the most notorious highly virulent disease in history is the Plague. During its worst outbreak in mediaeval times, it is estimated that up to half the population of Europe died of the Plague. The bacterium that causes bubonic and pneumonic plague was spread by fleas, which thrived on rats. This connection, and the specific pathogen, were not identified until the end of the 19th century, however.

Although accounts exist of extensive flu-like outbreaks as far back as the 16th century, it was not possible to document pandemics in biological terms until late in the 19th century. In the past 100 years, there have been four actual flu pandemics (all of the influenza A type):

•   The Spanish Flu in 1918–19 (H1N1)
•   Asian Flu in 1957–58 (H2N2)
•   Hong Kong Flu in 1968–70 (H3N2)

        and, most recently,

•   New influenza A in 2009–10 (H1N1 pdm09)

Spanish Flu (1918–19) was the disaster against which all pandemic risks are measured today. Contrary to what the name suggests, the disease was by no means confined to Spain. It is now estimated that around one third of the world's population at the time was infected with the disease. A total of 10–20 per cent of those infected died, equivalent to 3–6 per cent of the world's population at the time, or almost 100 million people. No other event in history has killed so many people in such a short time. The pandemic appeared in three waves (early spring of 1918, autumn of 1918, and late winter of 1919), with the second wave being the worst. The pandemic struck unusually hard among adolescents and young adults (around 80 per cent of those who died were between the ages of 15 and 45), and killed with great speed. Some of those infected who did not die from the viral infection within a few days, died of bacterial complications (mainly pneumonia), which in those days were difficult to treat as antibiotics had yet to be developed. It is thought that over 14,000 people died of Spanish Flu in Denmark. If we convert this to the current population of Denmark, this would be the equivalent of around 26,000 flurelated deaths.

In 2009, the new type of influenza A (H1N1 pdm09) caused the first pandemic of the 21st century. At the beginning, the pandemic was also referred to as 'swine flu', as the new virus contained elements of a swine flu virus. In April 2009, the first case of person-to-person

transmission was reported in Mexico. Shortly afterwards, cases were recorded in the USA, and within a few weeks the infection had spread throughout most of the world. By the time the World Health Organisation (WHO) declared a regular pandemic on 11 June 2009, 74 countries had reported laboratory-confirmed infections. At the end of the year, cases had been recorded in almost every country. On 10 August 2010, the WHO declared the pandemic as over. The H1N1 pdm09 virus is currently still in circulation, but as a normal seasonal flu virus, as there is no longer as much susceptibility to the disease in the population.

The outbreak of Ebola in West Africa (principally Liberia, Sierra Leone, and Guinea) from 2013–6 had no consequences in terms of health in Denmark, nor for any Danish citizens. Ebola is transmitted from person to person by direct contact with body fluids and is infectious only in cases of overt disease, i.e. when clear

symptoms of the disease are present. Ebola is thus not particularly contagious, but on the other hand it is a very serious disease with a fatality rate approaching 70 per cent (50–60 per cent for patients admitted to hospital). This was part of the reason why the outbreak still received a lot of attention in Denmark.

As well as the Danish contributions to the effort to combat Ebola in West Africa, extensive preparedness measures were carried out in Denmark. This included general information to the public, plans for the repatriation of any infected Danish personnel working in West Africa, and plans for the isolation and diagnosis of people who had returned to Denmark showing symptoms of Ebola. A very small number of patients were admitted for observation in isolation. These included a nurse who had been sent to Sierra Leone to assist with the efforts to combat Ebola.

Key Actors

- **Danish Health Authority**
- **Statens Serum Institut (national serum institute)**
- **Danish Patient Safety Authority**
- **Danish Medicines Agency**
- **Danish Regions**
- **Danish National Police**

- **Danish Emergency Management Agency (DEMA)**
- **Municipalities**
- **Pharmacies**
- **European Centre for Disease Prevention and Control (ECDC)**
- **World Health Organisation (WHO)**

What if…

…a new and hitherto unknown respiratory tract virus were to appear?
The virus spreads through the air and affects all age groups. Most develop a mild cold-like respiratory tract infection that passes by itself after a few days. However, around one in every 50 children under school age develops severe breathing difficulties that require assistance in hospital.

The disease spreads rapidly. Parents of small children are afraid of introducing the infection into their homes, and the emergency telephone lines are extremely busy. The strain on both general practitioners and hospitals increases, with paediatric units under particular stress.

At the same time, a large proportion of the staff in the health care sector and the rest of society are unable to go to work, either because they themselves have fallen ill or because they have sick children at home…

A microbiologist wearing protective, air-purifying equipment studies the properties of a reconstituted flu virus from the 1918–19 pandemic, also called 'Spanish Flu'. The catastrophic and global pandemic probably acquired its misleading name because the media in Spain – which was a neutral country in the First World War – were able to report freely on the outbreak.
Image: James Gathany/CDC

5.

Animal Diseases
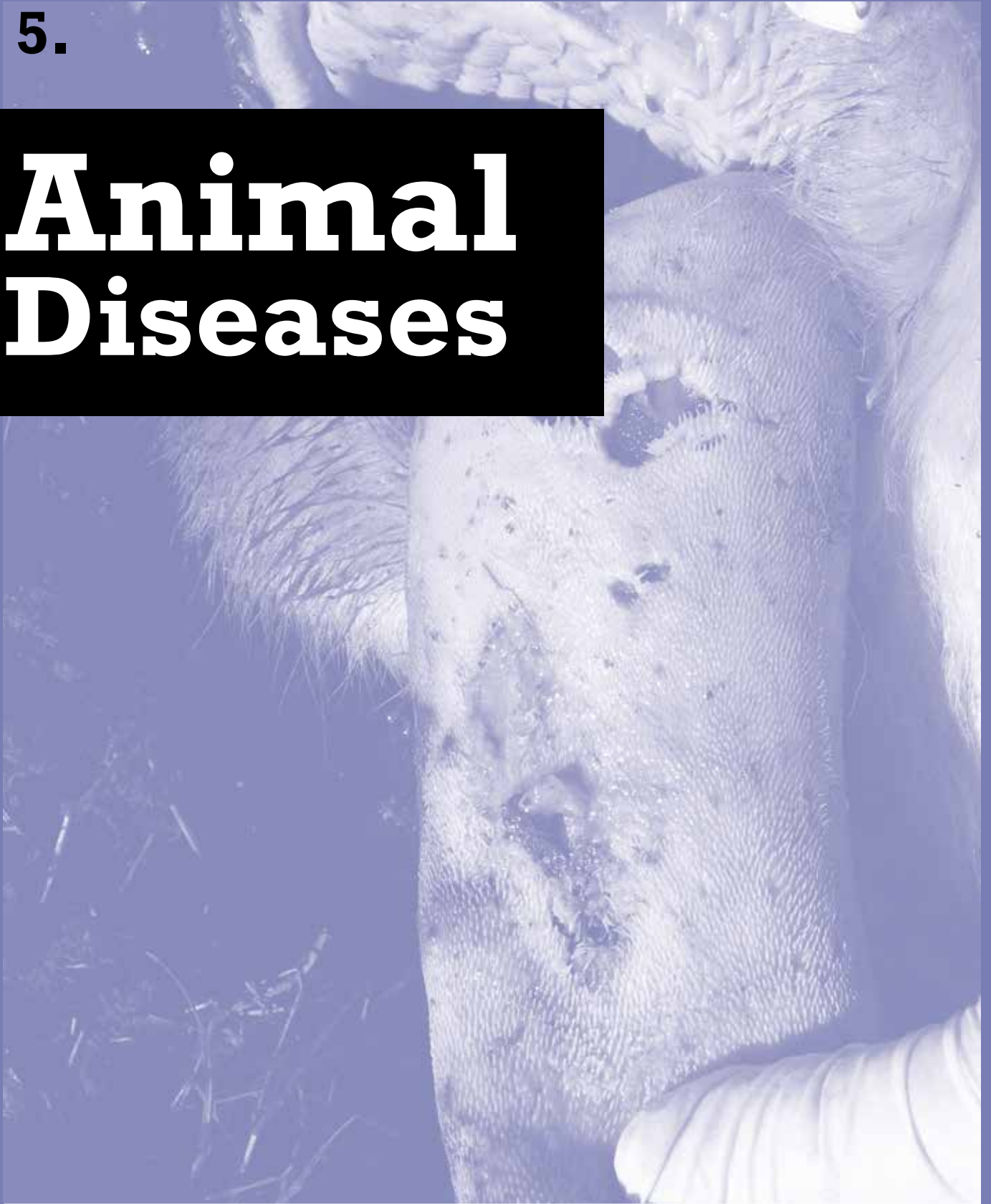
Clear signs of foot-and-mouth disease can be seen in the form of sores or blisters on the tongue and in the oral cavity. The picture shows a cow's tongue (Bulgaria, 2011). Image: Dr. Tsv. Alexandrov

In 2003
...avian flu of the serious type H5N1 broke out in parts of Asia and later spread to Europe and Africa. The virus has caused outbreaks among wild birds and poultry in over 60 countries, including 24 in Europe.

As well as creating problems for poultry production, this virus also represented a significant risk to people, and the outbreak ended up costing several hundred lives. There was also a fear that avian flu would develop into a virus with pandemic potential.

In Denmark, the serious H5N1 type was found three years later (2006) in both wild birds and in a hobby poultry flock.

Characteristics

Food production and domestic animals can be affected by outbreaks of a number of serious, infectious diseases in animals. Some disease outbreaks may be limited to a specific species, while others are also able to spread among species. When the number of infected animals rises dramatically, a disease outbreak can be termed an 'epidemic' or an 'epizootic'.

Animal diseases are primarily a threat to animal stocks themselves, but in certain cases diseases can be transmitted from live animals to people. A disease of this kind is called a 'zoonosis' (plural: zoonoses). A zoonosis that causes illness in people does not necessarily do so in animals. In other words, animals may be carriers of infection without showing symptoms themselves. Some zoonoses, however, lead to serious symptoms in both animals and people.

From a Danish perspective, the most serious animal diseases are high pathogenicity avian influenza (flu), African swine fever, classical swine fever, and foot-and-mouth disease.

Avian flu ('bird flu') is an infectious viral disease that can affect all species of birds and is caused by the influenza A virus. Avian flu can be divided into two types: High pathogenicity avian influenza (HPAI), which leads to extremely serious disease, and low pathogenicity avian influenza (LPAI), which causes milder disease in poultry. As LPAI has the ability to change into the high pathogenicity type, flocks of poultry infected with LPAI will be destroyed by the veterinary authorities. Infected birds shed the virus via secretions from the respiratory tract and through their faeces. The infection is easily transmitted, for example through infected feed and drinking water. Wild birds, particularly migrating water birds, can spread the infection from one part of the country to another and across national borders. Humans and other species of animals as well as poultry – pigs, for example – can also become infected with avian flu.

Classical swine fever and African swine fever are viral diseases that can infect all breeds of pig, including wild boar. The infection is transmitted from animal to animal within the individual herd by direct contact, as well as indirectly through bedding, feed, and water that has been contaminated with the urine, droppings, or nasal discharge of diseased animals, or by feeding food waste containing the virus. Transmission of infection

between herds can occur when pigs are traded, or via people who have been in contact with infected animals. When swine fever occurs in wild boar, it may lead to the transmission of infection to domestic pigs in the absence of an adequate infection barrier between them. This has been a contributing factor in the recurring outbreaks of the disease in Europe in recent years. The infection cannot be transmitted to people.

Foot-and-mouth disease is a serious infectious viral disease that can infect all species of cattle, pigs and wild ruminants, as well as sheep and goats. Infected animals shed the virus in their breath, saliva, dribble, milk, semen, droppings, and urine. For this reason, the disease can be transmitted not only from animal to animal by direct contact but also via products from infected animals. Semen from infected animals is infectious before clinical symptoms become apparent, and artificial insemination can therefore also spread the disease. The virus is found abundantly in milk, through which the disease can therefore be transmitted to the infected animal's offspring. Infected animals can shed the virus for several days before the symptoms of blisters are seen. Vehicles, or people who have been in contact with infected animals, can also transmit the virus. The infection cannot be transmitted to people.

Risk Outline

Occurrence

The Danish agricultural industry maintains a great focus on food safety and quality control. Denmark is covered by regulations from the EU, which are adapted to suit the conditions in Denmark and implemented in Danish law. Denmark works closely with the World Organisation for Animal Health (OIE) to secure high standards of animal health. Consequently, there are numerous serious infectious animal diseases that have never been detected in Denmark.

The OIE has officially recognised Denmark as being free of the following diseases: Rinderpest, foot-and-mouth disease, classical swine fever, African horse sickness, ovine rinderpest, and bovine spongiform encephalopathy (BSE). There have been no outbreaks of foot-and-mouth disease in Denmark since 1983, or of classical swine fever since 1933. Minor outbreaks of avian flu occur more frequently in Denmark. For example, two outbreaks of low pathogenicity avian flu were confirmed in two mallard flocks in 2016. Furthermore, in November 2016 the high pathogenicity avian flu (H5N8) was confirmed in a flock of poultry on Zealand, as well as in wild birds in several places in the country.

The risk of the introduction of serious infectious animal diseases in Danish domestic animal stocks will probably increase over the coming years. Globalisation, which brings increased movement of animals and people, increased trade between nations, and also climate change, can all increase the risk of both introducing new animal diseases and reintroducing ones that we already know. Of the newly introduced animal diseases, mention can be made here of the cattle disease known as Lumpy Skin Disease, first confirmed in an EU country (Greece) in 2015. The disease has now spread rapidly to several south-eastern EU countries.

The vector-borne viral disease West Nile Fever has been spreading in Europe since 2008, and the disease thus also poses an increased risk to Denmark. West Nile Fever is mainly found in birds, but at the same time it can be transmitted by a vector (in this case, a mosquito) to mammals – including horses and people, who are particularly susceptible. Even small rises in temperature and humidity can allow insects to survive in new areas and to propagate explosively in warm periods. During summer months in particular, insects would be able to spread exotic infectious diseases to both animals and people.

Given the extent of livestock production in Denmark, and the relative density of herds and flocks, outbreaks of disease may occur despite the constant efforts to reduce the risk factors. The serious infectious animal diseases are notifiable diseases in Denmark, which means that any suspected disease must be reported to the Danish Veterinary and Food Administration.

Challenge Pattern:

Animal Diseases

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES
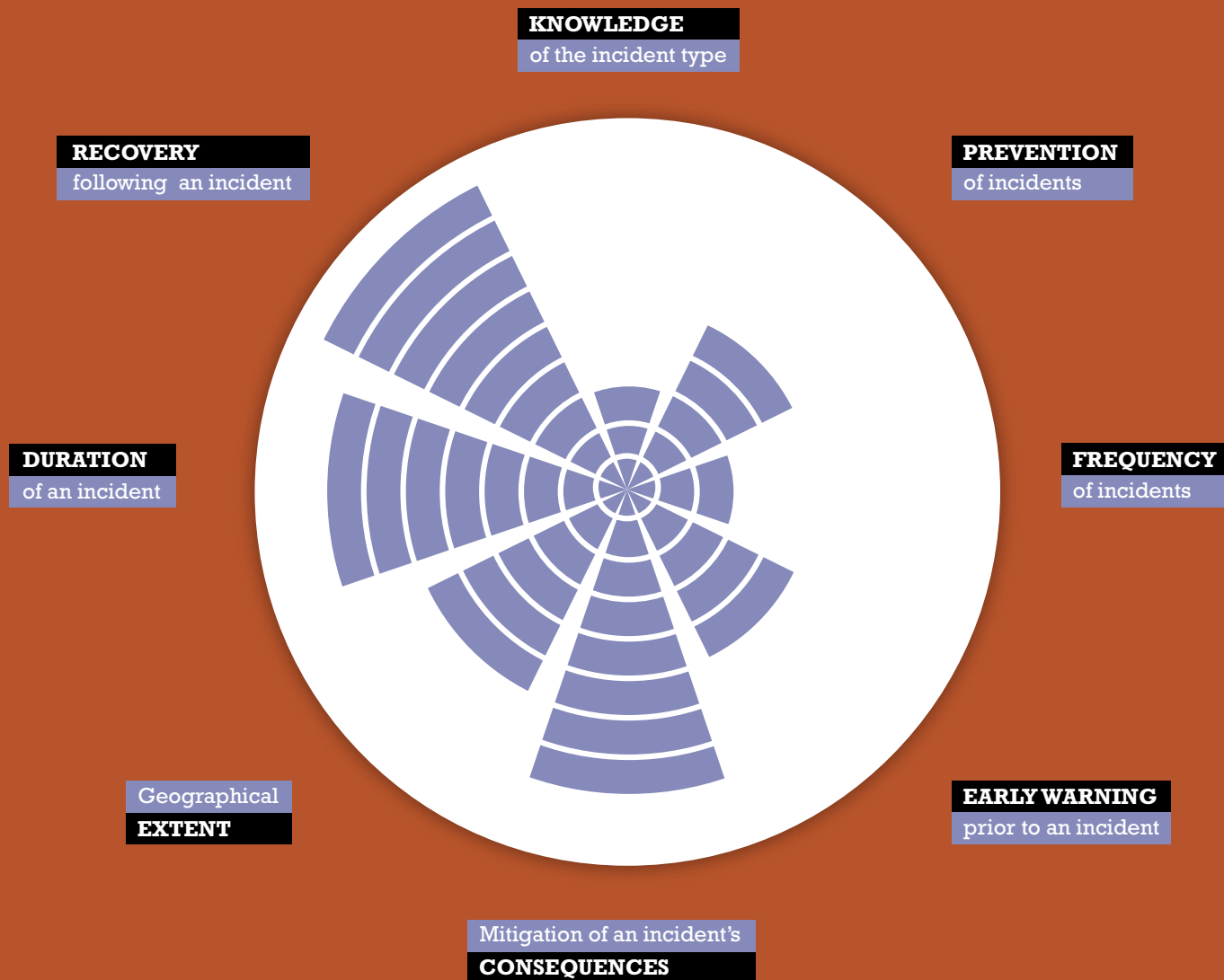
Many animal diseases are highly infectious, and an outbreak can therefore last a long time before the disease is be contained and defeated. An even longer recovery phase often follows, e.g. because of the need to regain confidence in the markets before sales and, in particular, exports can recommence. Long-lasting production and export losses can do lasting damage to the industry in question and have significant socio-economic consequences.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Consequences

The consequences for the health of infected animals can vary from mild symptoms to widespread mortality. Even animal diseases that are not directly fatal can cause permanent damage to the animals. For the serious infectious diseases, such as foot-and-mouth disease, swine fever and avian flu, the risk of spread is usually so great that stocks must be culled and the areas that have been occupied by the stocks cleaned and disinfected.
The consequences for humans affected by a zoonotic disease – particularly the influenza types – are addressed in Chapter Four under 'Highly Virulent Diseases'.

As well as the consequences for the health of animals and people, outbreaks of some animal diseases can have a major socio-economic impact. This applies particularly to the agricultural sector and other industries involved in the production and export of livestock and related foodstuffs. These economic consequences may include losses of production, expenses relating to diagnosis, treatment, destruction, cleaning and disinfection of contaminated areas occupied by infected herds and flocks, temporary restrictions on movement, and other measures aimed at containing the disease outbreak.

Agriculture is an important sector in the Danish economy. Livestock production mainly comprises cattle, pig, sheep, and poultry husbandry. Figures from 2014 show that the value of livestock production was DKK 51.8 billion, while that of plant production totalled DKK 26.2 billion. However, by far the greatest economic consequences will result from lost export revenue.

With total annual food exports amounting to over DKK 150 billion – equivalent to 25 per cent of Denmark's total goods exports – the potential for damage is enormous. Even minor outbreaks, where the situation is quickly brought under control – or, indeed, cases that prove to be false alarms – can have significant economic consequences. In the event of an outbreak of certain animal diseases in Denmark, other countries could impose comprehensive and long-lasting bans on the import of related food products from Denmark. Even without restrictions, there could be export losses, with consumers possibly seeking to avoid contact with Danish food products that could be linked to the disease. Not only that, but outbreaks could lead to failing confidence in the safety surrounding animal health and food production in Denmark. Such lack of confidence among Danish and foreign consumers alike could last a long time, and cause significant harm to the Danish agricultural market.

The direct costs of combating animal diseases can be high, but will typically be less than the commercial costs. To illustrate this, estimates have been calculated based on simulated outbreaks of foot-and-mouth disease in Denmark. These estimates show a fall in exports that is ten times greater than the costs involved in combating the disease using the strategies examined. The estimates further show that the total economic losses for each epidemic of foot-and-mouth disease can vary from DKK 3 billion to DKK 8.5 billion.

Consequence Pattern:

Animal Diseases

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

Examples

The most recent outbreak of foot-and-mouth disease in Denmark occurred back in 1983 in a consignment of cattle that had been moved from southern Funen to Zealand. The outbreak was the last of a more extensive epidemic that had originated in Ukraine and then spread via East Germany. The event led to long-lasting export restrictions and major economic losses.

The United Kingdom experienced a serious outbreak of foot-and-mouth disease in 2001. A total of 2,030 outbreaks were confirmed, leading to the culling of around 6 million animals and total costs of around DKK 40 billion. Satellite outbreaks also affected Ireland, France, and the Netherlands. A new series of outbreaks occurred in the United Kingdom in 2007 as a result of the release of virus from the country's reference laboratory. Large restriction zones were set up and there was a complete ban on the movement of animals within the country for a long period. Although there were by no means as many outbreaks confirmed as in 2001, the financial costs were high nonetheless as the world's confidence in the British agricultural industry fell.

For many years, bluetongue was described as a vector-borne disease confined to southern Europe, south of 50 degrees north. The disease is transmitted by biting insects and affects cattle, sheep, goats, deer, and other ruminants. In October 2007, the first outbreak was confirmed in Denmark, and in 2008 there were 15 outbreaks in the country. The outbreaks led to a comprehensive vaccination programme being initiated in Denmark, lasting from 2008 to 2010. The most recent outbreak of bluetongue in Denmark was in November 2008.

In 2015, there were outbreaks of African swine fever among wild boar in Lithuania. Outbreaks have occurred in both domestic pigs and wild boar in Estonia, Latvia, and Poland. It is assumed that the outbreak originated in Russia and Belarus.

From 2015 to 2016, there were 101 outbreaks of both high and low pathogenicity avian flu in France. These occurred among poultry flocks and included geese, ducks, chickens, hens, and guinea fowl. The episode closed down the country's production of foie gras for several months, leading to major export losses.

The disease BSE, also referred to as 'mad cow disease', is an example of an animal disease that struck completely unexpectedly. The disease is neither caused by viruses nor bacteria, but by the functional change of a certain type of protein. In Denmark, there have been 15 cases of BSE reported, with the most recent one being in 2009. Since 1984, the disease has led to the destruction of 180,000 cows in the United Kingdom. A further 4.4 million cows have been culled as part of the programme to eradicate the disease. The deaths of 177 people have been directly linked to out-breaks of BSE (as of June 2014). The direct financial costs resulting from BSE outbreaks have been considerable. It is estimated that the outbreaks cost a total of almost DKK 50 billion. As well as the fatal consequences of the outbreak to people, the British cattle industry suffered a hard blow as the EU subsequently banned imports of British beef. The ban lasted for ten years, although some countries maintained import restrictions for even longer.

Key Actors

- **Danish Veterinary and Food Administration**
- **Statens Serum Institut (national serum institute)**
- **Danish Emergency Management Agency (DEMA)**

- **Technical University of Denmark (DTU) – National Veterinary Institute**
- **Danish Patient Safety Authority**
- **Danish National Police**
- **Danish Health Authority**

What if…

…swine fever were to break out in one of Denmark's neighbouring countries?

After a short time, the disease appears on a number of different farms in Denmark. Even though measures are put in place – such as transport restrictions, culling of herds, cleaning, and disinfection of areas used by herds, and the establishment of zones around infected herds in which special regulations apply – it is not possible to stop the spread of infection. The infection spreads to all parts of the country, with numerous outbreaks being reported.

Danish and foreign consumers start to avoid Danish food products that have any connection with pig production. Not only that, a significant need for information develops among the public, who wish to know whether the disease poses a risk to people…

Animal diseases can be extremely infectious. This requires special precautions when handling potentially infected animals. The picture shows DEMA employees collecting dead wild birds at Gavnø Castle during the avian flu outbreak in 2006.
Image: SCANPIX

6.

Water and Foodborne Diseases

Cucumbers were wrongly suspected of being the main source of a very large outbreak of VTEC in Germany in 2011.
Image:Colourbox

August 2014
In the summer of 2014, Denmark experienced the highest mortality rate seen in a single outbreak of foodborne disease. A total of 41 people were infected with listeria, 17 died as a result of infection. The patients were relatively evenly distributed across the regions in Denmark. The outbreak lasted for several months before it was under control.

It emerged that the main source of listeria infection came from rolled sausage products from a manufacturer in Zealand. Other companies bought and used products from this company to produce sliced sandwich toppings. The listeria bacteria were transferred onto these companies' slicing equipment, and could from there infect other products with listeria.

Characteristics

Water and foodborne diseases, often referred to as 'food poisoning', are caused by the contamination of water and food products by a broad range of micro-organisms, such as bacteria, viruses, parasites, and fungi. Some bacteria also produce toxins, which can lead to disease. A foodborne disease is caused by the micro-organisms (bacteria, viruses, etc.) themselves, while foodborne intoxication (food poisoning) is caused by toxins, e.g. those produced by bacteria or fungi, or chemical toxins.

Waterborne diseases include infections with parasites, bacteria, viruses, and algae. These enter the body when a person drinks contaminated water, or as aerosols through body orifices and open wounds. Water quality in Denmark is generally high. The water supply in Denmark is almost exclusively based on the extraction of groundwater, and the Danish water supply structure is highly decentralised. This means that, in the vast majority of cases, an outbreak of waterborne disease will be very local. An increase in the incidence of waterborne diseases is a common after-effect of flooding – for example, when flooding causes wastewater to rise up from sewers, or if a water purification plant is subject to flooding.

Foodborne diseases are typically bacterial infections and vary in seriousness. Foodborne infections may be due to the consumption of food products that are infected as a result of poor hygiene in the food industry, poor kitchen hygiene, or a failure by the consumer to thoroughly cook the food, for example when handling raw meat. Fruit and vegetables that have been washed in contaminated water is another possible source of infection.

Food poisoning caused by toxins from toxin-producing bacteria (e.g. Clostridium botulinum), or other chemical substances, is considered to pose a particular problem, as the consequences for those affected can be long-lasting and life-threating. Water and foodborne infections are the cause of many serious cases of illness. Population segments with a particular vulnerability to foodborne infections vary with the pathogen, but overall they include children, the elderly, people with impaired immunity, and pregnant women. The World Health Organisation estimates that there are around 23 million cases of illness a year in the EU region caused by a foodborne infection. Pathogens considered able to have a serious impact on public health in Denmark include norovirus, campylobacter, listeria, and VTEC (verocytotoxin-producing E. coli).

Norovirus – which in Denmark also goes by the name 'Roskilde disease', as the first outbreak in Denmark was registered in the town of Roskilde – is highly contagious. The virus can spread in air droplets in the same way as, for example, the common cold virus, and it takes but very few virus particles to make a person ill. This is a common method of transmission for virus infections, and it explains why large groups of people can become infected. Gastrointestinal infections can also be caused by campylobacter. The bacteria are typically found on the surface of raw chicken, but cases have also been seen where sources of drinking water have become contaminated with norovirus and campylobacter. Possible sources of salmonella infection include pork, eggs, poultry, fish, vegetables, etc. In certain cases, VTEC infections can be very serious and lead to organ failure caused by the toxins produced by the VTEC bacteria. Another danger to human health is, for example, botulism – also known as 'sausage poisoning'. Botulism is caused by toxins from the bacterium Clostridium botulinum, which produces neurotoxins. Neurotoxins are some of the most potent and dangerous toxins of all. Botulism is usually caused by poor preservation of food products. Water and foodborne diseases caused by infection with parasites are rare in Denmark.

Risk Outline

Occurrence

In Denmark, the most frequent causes of water and foodborne diseases are norovirus and campylobacter. In 2015, a total of 16 outbreaks of norovirus were recorded, with between seven and 142 people infected. In the same year, two outbreaks of campylobacter were reported, with 25 and 110 people infected, respectively. The annual figures for people with laboratory-confirmed campylobacter infection in the past decade have varied between 3,239 (2006) and 4,372 (2015).

In the years leading up to the turn of the millennium, salmonella infection was even more common than infection with campylobacter. However, greater awareness of salmonella among the population, combined with preventive and combative measures by the authorities, has led to a pronounced drop in the number of salmonella infections, which in recent years has been at a level of around 1,000 cases per year. Particular mention should be made in this regard of the efforts that have succeeded in eliminating salmonella from chickens raised for consumption and egg production. In 2015, there were three outbreaks of salmonella, with between six and 14 people infected.

VTEC also causes foodborne diseases in Denmark. One outbreak of VTEC was recorded in 2015, resulting in three people becoming infected.

Poisoning caused by bacterial toxins also occurs in Denmark. Each year, a few cases of botulism – predominantly infant botulism – are recorded in Denmark. In 2015 there were 11 recorded outbreaks of Clostridium perfrigens, with between eight and 80 people falling ill as a result, and one outbreak involving six cases of illness due to the growth of Bacillus cereus in food. These two species of bacteria produce toxins that, if ingested, can produce a severe but short-lasting illness, with either diarrhoea or vomiting.

The true number of cases of water and foodborne diseases is assumed to be somewhat higher than the numbers reported. For one thing, this is due to the fact that the symptoms of infection overlap with a number of other illnesses and, for another, that people with milder forms of infection typically do not seek medical attention but rather self-treat the symptoms of the infection without specific reference to the source of the illness.

In some cases, dietary supplements have been shown to contain illegal and harmful substances, or undeclared ingredients. A dramatically increased intake of vitamins and minerals – for example, as a result of manufacturing errors or poor labelling – can be damaging to health.

Cases involving the manufacture and sale of illegal food products appear to be increasing in the EU, a trend that is expected to continue. The danger with food product fraud is that neither consumers nor the authorities can know with any certainty what substances the products contain, nor where and under what hygiene conditions they have been manufactured.

Repackaging, inappropriate refrigeration conditions, and fraudulent expiry date labels can also increase the risk of infection. Greater risk is therefore associated with the consumption of illegal food products. Adding to that, it can be more challenging to resolve outbreaks of illness, due to the dubious traceability information in cases of food product fraud.

Challenge Pattern:

Water and Foodborne Diseases

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES
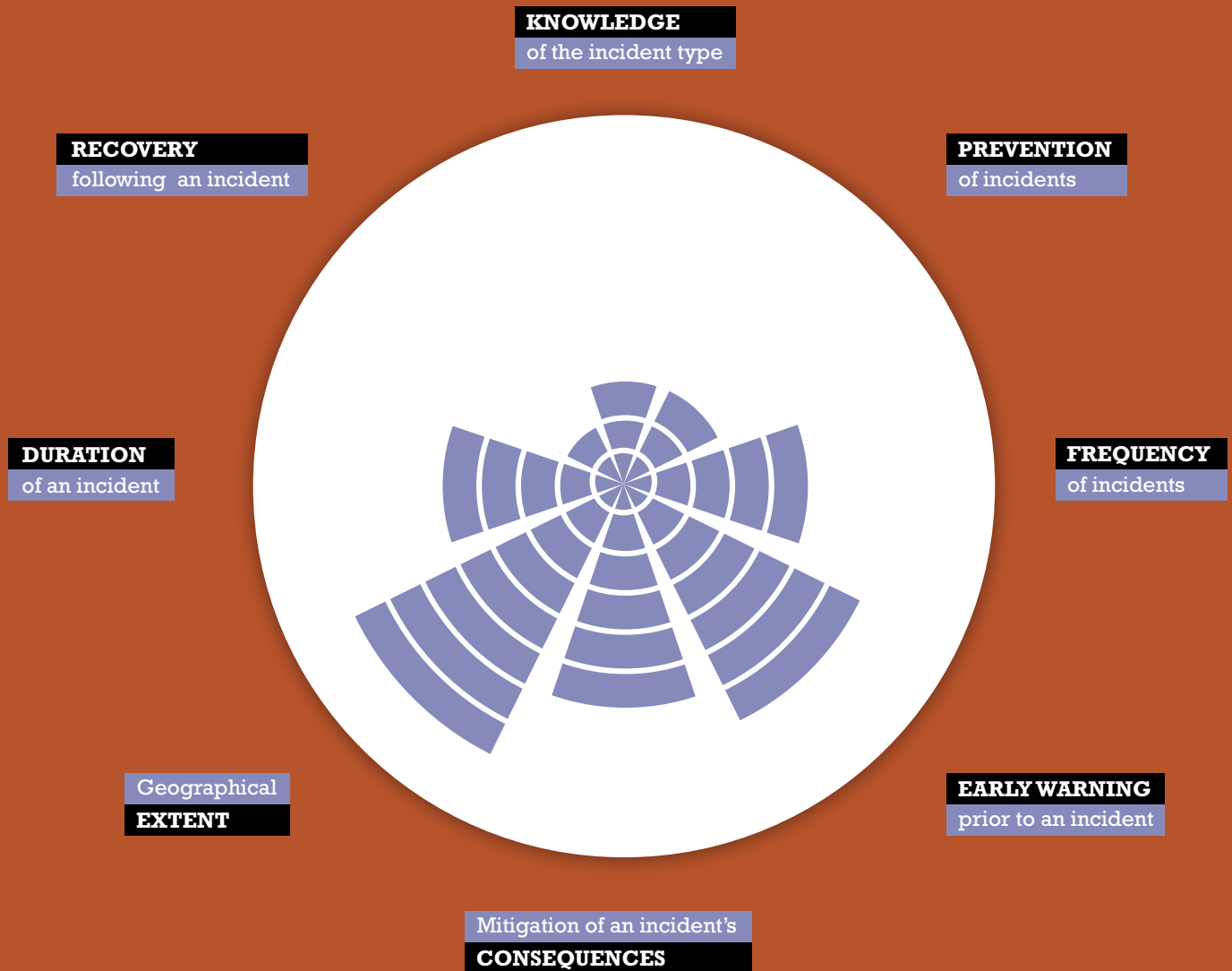
Water and foodborne diseases may be local phenomena, but many products are also distributed widely and to a large number of consumers. Cases of illness can thus be spread across the entire country, across national borders, and even worldwide. Warning the public may present challenges in cases where an outbreak has been identified but the source of infection is unknown.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Consequences

Water and foodborne diseases can cause unpleasant and serious symptoms, and in the worst cases they can prove fatal.

The most common health-related consequences of water and foodborne infections are gastrointestinal infections, with symptoms such as stomach pain, diarrhoea, and vomiting. These can be serious enough to require hospital treatment. Examples of this include infections with norovirus, campylobacter, and salmonella.

Listeria infections may, among susceptible groups – e.g. patients with impaired immunity and pregnant women – lead to life-threatening complications such as blood poisoning or meningitis. VTEC often causes severe stomach pain and bloody diarrhoea, and in severe cases it can lead to haemolytic uraemic syndrome (HUS). HUS is a serious and potentially life-threatening condition that can cause permanent kidney or neurological damage. HUS resulting from a VTEC infection primarily affects children, in whom it is the main cause of acute kidney failure.

Botulism poisoning can also have very serious consequences. The bacterial toxin attacks the nerves and causes paralysis. Botulism can therefore lead to permanent damage. In extreme cases, where the muscles of the chest are paralysed, the infection can be fatal. Treatment for botulism infection can last for several months.

A contamination of drinking water supplies can last for a long time. As well as the risks of disease, this can cause inconvenience to companies and the public in the affected area.

The sale of illegal food products can have serious consequences for food safety in Denmark. Consumers are at risk of ingesting products that contain toxic substances, or ingredients that provoke allergies, and which are not declared on the product. The consequences can range from minor discomfort to death.

Foodborne diseases can also have serious economic consequences. For example, if entire batches of a production need to be recalled. In some cases, the mere suspicion of contamination may be enough to warrant a recall. Production facilities, canteens, restaurants, etc., may need to be closed down following identification of foodborne pathogens. These shutdowns can prove costly and jeopardise the reputation and the existence of a busines.

Moreover, water and foodborne diseases can lead to import and export bans being imposed on certain ingredients or processed products. This can have a major impact on manufacturers and, at the same time, puts the entire Danish foodstuffs export to specific countries at risk.

Hospitals may experience an increase in the number of patients requiring special treatment that exceeds their ready capacity. Authorities and players in the health care and food sectors may face a great pressure trying to meet the demand for information from the public.

Consequence Pattern:

Water and Foodborne Diseases

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Examples

In 1999, dioxin was found in chicken feed in Belgium. Dioxin is a toxin that, among other things, can lead to an increased risk of cancer, hormone disturbances, and reproductive disturbances. The issue of the contamination of food products through the food chain became a major political topic in Belgium as a result of the scandal. Confidence in food safety plummeted and consumers began to buy meat and dairy products from other countries, forcing many Belgian farms to close. The cost of the scandal exceeded 625 million euros.

Although the incident was not an emergency in health terms, the example illustrates the possible economic consequences that may result from toxins in food products.

At the beginning of 2007, the drinking water of 7,000 members of the public in Køge was contaminated. Due to a fault at a cleaning plant, wastewater had been diverted into the drinking water pipes via a connecting section. In total, 120 people were taken ill. Køge experienced a further incidence of drinking water pollution in June 2010, when several people were confirmed to have been infected with campylobacter.

From the beginning of 2008, Denmark experienced its biggest outbreak of salmonella since monitoring began in 1980. Despite extensive efforts, it was not possible to trace the source. From the start of the outbreak until 1 September 2009, 1,206 cases of salmonella U292-related illness were recorded, evenly distributed throughout the whole country.

In the summer of 2011, Germany experienced a very major outbreak of VTEC with HUS. It was an unusual outbreak in that the group most affected were adult women, not children. A total of 908 cases of HUS and 3,168 cases of VTEC were reported, with 53 deaths attributed to the outbreak. Fenugreek shoots produced from Egyptian fenugreek seeds were identified as the most likely source of the outbreak. During the epidemic, suspicion had fallen on a number of other food products as possible sources of the infection, including tomatoes, cucumbers, and lettuces. These suspicions, along with warnings from the authorities, led to a de facto ban on the import of Spanish cucumbers and to major economic losses of up to 80 per cent of sales for a number of German businesses. Danish cucumber and lettuce producers were also affected – mainly due to consumers' reaction to the suspicion and the resulting dramatic fall in demand.

In July 2016, a product containing vitamin D in liquid form for babies and toddlers had to be recalled from shops throughout the country. A calculation error by the manufacturer meant that the drops contained 75 times more vitamin D than they should. Such a high concentration is harmful to health. Vitamin D poisoning causes vomiting, headache and, in rare cases, seizures and kidney failure. The product was recalled immediately, but around 500 bottles had already been sold. By 1 August 2016, 150 children had been examined, with 74 of them showing signs of poisoning. Of these, six children were severely poisoned.

Key Actors

- **Danish Veterinary and Food Administration**
- **Danish Health Authority**
- **Statens Serum Institut (national serum institute)**
- **Danish Patient Safety Authority**

- **Danish Environmental Protection Agency (EPA)**
- **Technical University of Denmark (DTU) – National Food Institute**
- **Danish Regions**
- **Municipalities**

Opposite page: The quality of drinking water in Denmark is very high. However, given special circumstances the water may be contaminated with disease-causing organisms (pathogens) that cannot be tasted nor smelled. Because of the decentralised water supply structure, an outbreak of a waterborne disease in Denmark would usually be highly localised. Image: Colourbox

What if..

…a sudden dramatic increase in the number of infections with a special type of HUS-inducing VTEC were seen in Denmark?

Among those infected are many children, and investigations among patients raise the suspicion that milk or a milk-based product may be the source of the outbreak. Cases are being reported countrywide. After just a few weeks, the number of HUS-related deaths is at 20.

The source of infection has now been identified, but consumers and export markets nonetheless avoid a wide range of dairy products.

Hospitals in Denmark have reached maximum capacity for treating patients with HUS and begin to contact the German and Swedish health authorities for help.

7.

Nuclear Accidents

The most serious nuclear accident in history to date occurred in 1986 at the nuclear power plant at Chernobyl. A cloud containing large quantities of radioactive particles then drifted over most of Europe, contaminating areas in numerous countries. The contamination can still be measured today. This picture is taken in 2010 and shows the on-going efforts to contain the radioactive fallout at the incident site, decades after the accident. Image: Danish Emergency Management Agency (DEMA)

Fukushima 2011
In March 2011, Japan was hit by a very powerful earthquake followed by a tsunami, which inflicted serious damage to the Fukushima Daiichi nuclear power plant. The incident caused a release of radioactive material from several of the plant's reactors, necessitating the evacuation of tens of thousands of people.

Although to this date we do not know of any deaths or illnesses caused by the radiation, the release has had enormous financial and economic consequences.

The incident at Fukushima led to the radioactive contamination of eight per cent of Japan's land area, including areas 200 km from the nuclear power plant.

Characteristics

The International Atomic Energy Agency (IAEA) defines a nuclear accident as an accident at a facility where nuclear materials are produced, processed, used, stored, or deposited. In this context, the term 'nuclear materials' refers exclusively to plutonium and enriched uranium. A distinction is thus made between nuclear accidents and radiological accidents, in that radiological accidents can occur involving radioactive materials other than plutonium and enriched uranium. For example, mention can be made here of radioactive materials used in industrial or medical facilities.

Nuclear facilities at which a serious accident could entail major consequences for Denmark first and

foremost include European nuclear power plants. Nuclear power plants occupy a special position as possible sources of nuclear accidents owing to the very large volumes of fission products they hold. Given unfavourable conditions, these have the potential for serious airborne spread of radioactive contamination over large distances.

However, a nuclear or radiological accident could also occur during the production and processing of reactor fuel aboard nuclear-powered vessels, at storage facilities and depots for spent fuel and radioactive waste, during transportation of spent fuel and radioactive waste, or during the handling of powerful industrial sources such as those used in radiography.

Risk Outline

Occurrence

There are no nuclear power plants in Denmark. It should be mentioned, however, that Denmark did previously operate three experimental reactors at the former Risø Research Centre, which is no longer operational.

Today, around 10,000 m³ of radioactive waste is stored at Risø next to Roskilde Fjord. A decision has yet to be made designating an intermediate or final storage depot for this waste.

The nearest operational nuclear power plant to Denmark is the Ringhals plant in Sweden, which has four reactors and is situated near Gothenburg, around 65 km from the Danish island of Læsø. On the German side, the nearest active nuclear power plant is Brokdorf, a distance of 105 km from the Danish border. Two further German nuclear power plants, Emsland and Grohnde, and the Oskarshamn nuclear power plant in Sweden, all lie within a 300 km radius of the Danish border. The closest Dutch, Belgian, French, and British plants are located at distances of around 500–600 km from Denmark. There are more than 170 operational reactors in Europe, three-quarters of which lie closer to Denmark than does Chernobyl, where the world's most serious nuclear accident to date occurred in 1986. Currently, there are 128 reactors in operation in 14 EU member states (Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom). The remainder are located outside the EU, including in Russia, Switzerland, and Ukraine.
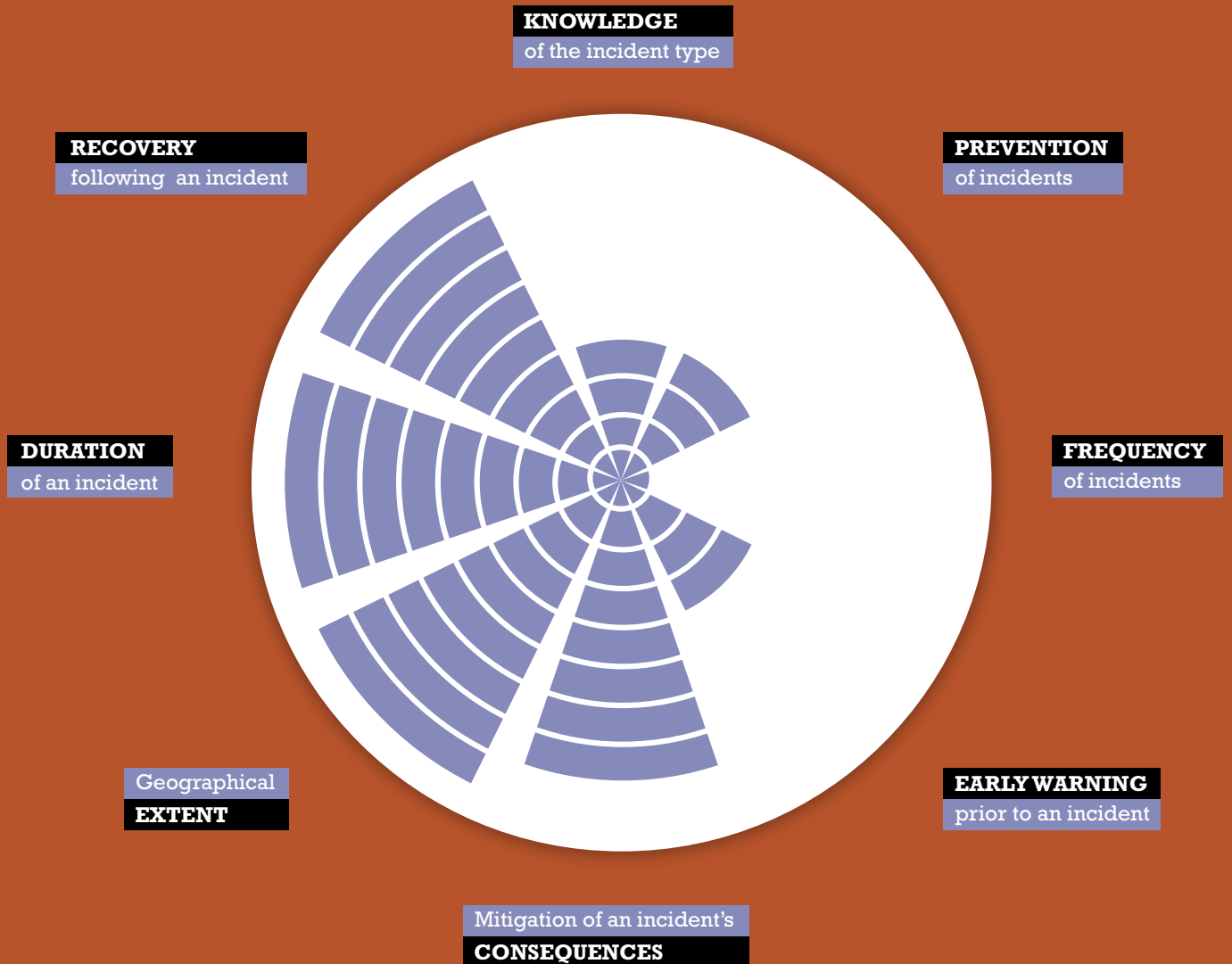
Although there are no nuclear power plants in Denmark, it is nonetheless possible for a nuclear accident to occur on Danish territory.

Nuclear-powered icebreakers regularly pass through Danish waters. Currently, several nuclear-powered icebreakers are under construction in Saint Petersburg, and these will pass through Danish waters on their way to the Murmansk region. Even though nuclear-powered cargo vessels and military vessels do not normally sail close to Danish territory, the possibility of this changing in future cannot be excluded. Russia has also started to build floating nuclear power plants, and in 2017 a plant of this type – complete with fuel – will, for the first time, be towed through Danish inland waters. In the event of a collision, a grounding, or other accidents, nuclear-powered vessels may release radiation if damage is incured to the reactors or their safety systems. Reactors used aboard ships are significantly smaller than those used in nuclear power plants. However, the shielding is less extensive and less able to withstand physical or mechanical stress.

The biggest danger associated with the operation of reactors is the risk of the release and spread of radioactive materials from the reactor fuel. In order for large quantities of radioactive material to be released, the fuel would have to be damaged and, at the same time, the reactor vessel and containment would have to fail in containing the radioactive materials released. This could happen if the ability to control the chain reaction in the reactor core, or to cool the core effectively, were lost. Something similar can happen if it is not possible to cool the spent fuel in the fuel pools, which are often placed outside the reactor containment.

Triggering factors may be technical vulnerabilities in systems, human error, or the effects of other incidents such as natural disasters or faults in the electricity distribution network.

Challenge Pattern:

Nuclear Accidents

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Nuclear incidents can extend over large distances and affect a number of countries at the same time. Radioactive contamination can have a widespread impact and persist for many decades. Recovery efforts following an incident can therefore also be both very costly and protracted.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Consequences

In the event of a release into the atmosphere following an accident at a nuclear reactor, it is the quantity and nature of the radioactive materials, combined with the meteorological conditions, that will determine the consequences of the release. How much radioactive material that is ultimately released into the sorroundings is therefore subject to the specific course of events in an accident. It is not possible to indicate a normal distance across which contamination spreads, as this is influenced heavily by factors like wind speed and washout in rain or other precipitation. As an example, following the accident at Chernobyl, significantly increased levels of radiation were measured in parts of Sweden and Norway, more than 1,500 km from the site of the accident. Depending on the nature of the accident, contamination in Denmark may occur locally or across the entire country.

For the same reason, it is difficult to estimate the consequences of nuclear accidents in Denmark. Under certain weather conditions, airborne releases may move long distances with relatively little fallout occurring on the way, followed by extensive washout as a result of precipitation, which can lead to significant contamination far from the site of the release.

Irrespective of weather conditions, direct radiation from contaminated air, or the inhalation or ingestion of radioactive materials through food products and drinking water, are not expected to cause any acute radiation damage to people in Denmark, even following an accident at a nuclear power plant close to Denmark or in the reactor of a ship sailing in Danish waters. An emergency management effort would therefore focus on keeping public radiation doses to a minimum in order to reduce the risk of long-term radiation damage (typically cancer). Consequences for health of a psychological nature are possible in both the short and the long term. There may, for example, be trauma or general anxiety caused by the accident itself, or by the stress and insecurity ensuing an evacuation of citizens. As a serious nuclear accident could potentially contaminate very large areas of land, the economic costs associated with clean-up could be enormous and last for several decades. This could affect agriculture in particular, where it may be necessary to destroy crops and cull livestock to avoid further contamination of food products and the derived consequences to our food supply and agriculture. In the event of radioactive contamination in Denmark, other countries' bans on the import of Danish products could lead to major and long-lasting losses of income. This applies even in the absence of import restrictions, as Danish and foreign consumers would presumably seek to avoid contact with food products from Danish agriculture, fishing, aquaculture, and fish farming.

A further consequence may be radioactive contamination of buildings and infrastructure, which could entail major clean-up expenses and, in the longer term, cause a significant deterioration in the value of property and land in contaminated areas. In the event of very severe contamination, it may even be necessary for the local community to be temporarily evacuated or permanently moved. This could involve significant costs and legal challenges. Moreover, even limited contamination – or simply a suspicion of contamination – may cause tourists to keep away for a time, with associated consequences to the tourism industry and the economy in general in the affected local communities.

Finally, a nuclear accident may lead to significant pressure on Danish authorities. This applies even if an accident occurs far away from Denmark and none of the consequences discussed above occur on Danish soil. The reason for this would be a great need for information among the public in Denmark, among Danes close to the site of the accident, and with regard to Danish commercial interests in the area. A long-term communication programme may be required in respect of health-related arrangements, precautions for travel, imports, etc.

Consequence Pattern:

Nuclear Accidents

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Examples

To date, no serious nuclear incidents have occurred on Danish soil. However, two nuclear incidents abroad have led to limited direct or indirect consequences in Denmark: the Chernobyl accident in the former Soviet Union in 1986 and the Fukushima Daiichi accident in Japan in 2011.

The Chernobyl accident was the most serious nuclear accident in the world to date. The accident occurred on 26 April 1986 after one of the reactors at the nuclear power plant at Chernobyl went out of control during a test performed in connection to a routine shutdown. This caused an explosion and set the reactor core on fire. Over a period of ten days, large quantities of radioactive material were sent several kilometres up into the atmosphere. From there, the contamination spread across large distances with the wind.

Changing wind directions drove the radioactively contaminated cloud in over most of Europe. A small increase in radiation levels was detected in Denmark, but there was no significant contamination, due to the very limited amount of precipitation at the time when the radioactive cloud passed over the country. By contrast, there was heavy rain in parts of Sweden, causing large quantities of radioactive material to wash out and lead to contamination there.

The Fukushima Daiichi accident occurred on 11 March 2011, when Japan was hit by a very powerful earthquake followed by a tsunami, which led to extensive destruction along the eastern coast. A number of the country's nuclear power plants sustained some damage, with the most serious being the Fukushima Daiichi plant around 250 km north-east of Tokyo. The damage following the tsunami disabled a number of emergency systems at the plant, making it difficult to cool the fuel elements in some of the plant's six reactors. As most monitoring systems malfunctioned at the same time, it was not possible to gain an adequate overview of the situation. A series of explosions took place in a number of the reactor buildings, and at times greatly increased levels of radiation were recorded.

Because of the distance from Japan, there was no risk of any direct consequences in Denmark, but Danish authorities, companies, and citizens at home and abroad had to decide how to approach a range of indirect consequences. Given the deteriorating situation at the Fukushima Daiichi plant in the days following the earthquake and tsunami, DEMA and the Danish Health Authority (unit for Radiation Protection, SIS) provided advice e.g. accompanying the travel guidelines for Japan issued by the Ministry of Foreign Affairs of Denmark. For a time, the advice was that Danes staying less than 80 km from the plant should leave. Also, it was recommended to avoid all travel to Japan for a while.

Neither at Chernobyl nor Fukushima has the decommissioning work or the work to limit the release of radioactive material into the surroundings of the plant been completed. At both accident sites, it is expected that these processes will take several decades and cost several billions of Danish kroner.

Opposite page: There are various types of nuclear-powered vessels that could potentially enter Danish waters. For example, Russian nuclear-powered icebreakers regularly pass Denmark on their way from the Baltic Sea to their area of operation, for example in the Barents Sea, and back. The picture shows the nuclear-powered icebreaker Yamal next to the nuclear-powered cargo ship Sevmorput. Image: Christopher Prentiss Michel

Key Actors

- **Danish Emergency Management Agency (DEMA)**
- **Danish Meteorological Institute**
- **Danish National Police**
- **Ministry of Foreign Affairs of Denmark**
- **Danish Veterinary and Food Administration**
- **Danish Health Authority**
- **Danish Environmental Protection Agency**
- **Danish Nature Agency**
- **Danish Agricultural Agency**
- **Danish Patient Safety Authority**
- **Danish Regions**
- **Municipalities**

What if…

…a nuclear-powered vessel were to collide with another ship in Danish waters?
As a result of the collision, both ships run aground just a few kilometres off the Danish coast. During the collision, the reactor's containment and cooling systems sustain serious damage.

A short time later, there is a release of radioactive material, which moves with the wind over Danish land and falls as radioactive rain spread across a number of municipalities.

The radiation level is not immediately life-threatening, but the long-term effects on society, the environment, and the economy may be considerable…

8.

Accidents Involving Chemical Agents

Efforts following an accident involving chemical agents in Glostrup, in which a corrosive liquid leaked from a 1,000 litre tank and contaminated a stock of foodstuffs. When cleaning up after an accident involving chemical agents, particular attention is paid to ensure that the substances are not spread further by evaporation to areas where people are located, or into the environment by seepage or drainage into the sewer system. Image: Danish Emergency Management Agency (DEMA)

On 3 February 2016

…a 10,000 m^3 tank of nitrogen-containing fertiliser collapsed at a company's premises in the Port of Fredericia. During the collapse, another tank at a neighbouring company's premises was damaged. This tank contained palm oil.

Large quantities of both substances leaked into the industrial area, where they ignited and a major fire developed. The heated palm oil was difficult to extinguish. A number of tanks in the vicinity collapsed due to the build-up of heat, and there was a danger of explosion. In conjunction with the incident, several hundred members of the public had to be evacuated from the area, institutions were closed, rail services suspended, and roads in the vicinity were impassable.

It was subsequently possible to collect the palm oil from the harbour area and neighbouring beaches, and hardly any lasting environmental damage was caused by it. However, about 5,000 tonnes of nitrogen leaked from the fertiliser tank, a large proportion of which ran into the Lillebælt strait. Equivalent to a full year's emissions of nitrogen from agriculture and towns combined, this was the largest single discharge of nitrogen ever in Denmark.

Characteristics

Accidents Involving Chemical agents are usually either industrial accidents or transport accidents, where – in the event of a fire, an explosion or a discharge – the hazardous properties of the substances involved may constitute a significant danger to people, property, and the environment. This applies particularly to flammable, explosive, and toxic substances. This section deals solely

with accidents on land, as accidents at sea are described in chapter nine, 'Maritime Accidents'.

Major accidents involving chemical agents occur when matters get out of control during manufacture, transport, storage, or use. Typically, large stockpiles of chemicals are found in connection with industrial plants. However, significant accidents can also occur, for example, in the event of releases of ammonia from air conditioning units in shopping centres and other buildings that cannot be described as industrial operations.

Businesses with large stocks of flammable, explosive, toxic, and environmentally harmful substances are classed as 'high-risk industrial establishments'. There are many types of high-risk establishments in Denmark, with oil storage instal-lations and refineries being to the largest ones. The regulations governing high-risk establishments are administrated by a number of authorities in Denmark and have their base in the EU directive referred to in everyday parlance as

the 'Seveso Directive'. The name is a reference to the industrial accident that took place in 1976 at a chemical processing plant at Seveso in Italy, which led to almost 2,000 people being treated for dioxin poisoning, the evacuation of over 600 people, and long-lasting environmental damage over an area of land covering 25 km^2.

The Seveso Directive, along with a number of other sets of regulations (including the EU's REACH regulation, and the pesticide and biocide directives), identifies a long list of chemicals with particularly dangerous properties. For example, in the group of toxic gases, ammonia is one of the most commonly found hazardous substances in Denmark. Ammonia is found, for example, in flue gas cleaning systems at power stations, in refrigeration units for food production, and in many other industries. Ammonia is stored as liquid gas under pressure. Therefore, it is quickly released if a tank or pipe etc. is breached. The gases are toxic if spread through the air, and in some cases can be a fire and explosion hazard.

Risk Outline

Occurrence

Industrial accidents and transport accidents involving hazardous chemicals could potentially happen in many places. In Denmark, there are around 150 registered high-risk establishments, some of which are located in or close to populated areas, such as harbour areas. In a number of places railway lines and road transport routes for hazardous goods pass through densely populated areas, although special routes are prescribed for the transportation of certain hazardous chemicals.

However, the basis for accidents involving chemical agents is not solely constituted by high-risk establishments. Storage companies, which temporarily store goods for onward transport and distribution, may also store substances that could constitute a hazard in the event of a leak or fire.

Common substances – such as artificial fertilisers, oil products, strong acids, and chlorine – can, when combined with other substances, become explosive, exceptionally flammable, toxic, and/or very harmful to the environment. Large stocks of refined oil products are kept throughout Denmark as part of the effort to insure stable fuel supplies. The potential causes of chemical accidents can essentially be divided into human error, technical errors, and external causes, although often a combination of several causes is at play.

Human error includes direct operator error – for example, the conscious or unconscious neglect of safety procedures or lack of attention. Human error can also be more systemic issues, such as inadequate safety culture, lack of auditing, poor maintenance, or inappropriate facilities. Conscious cutbacks on staff or facilities can themselves increase the risk of systemic, human error.

Technical errors may arise in equipment or systems, for example wear and tear that has gone unnoticed, build-up of static electricity, or the unintended presence of other sources of ignition. External risks cover circumstances or events outside the company or operation, such as extreme weather events, accidents at neighbouring operations, or deliberate sabotage of physical installations or IT systems.

Consequences

Thanks to a substantial focus on safety and prevention, accidents with chemical agents rarely have catastrophic consequences, although the potential for this is still there. In some cases, there will be a direct risk to life and health from the inhalation of gases and contact with liquids. As chemical accidents can often also involve explosions and violent fires, they can also result in many deaths and severe injuries at – and in the immediate vicinity of – the accident site. These happen as a result of pressure waves, strong radiant heat, collapsing structures, and the spread of smoke and toxic gases. In particular, the airborne spread of large quantities of hazardous chemicals in densely populated areas can have serious health consequences in the form of acute injuries to multiple people.
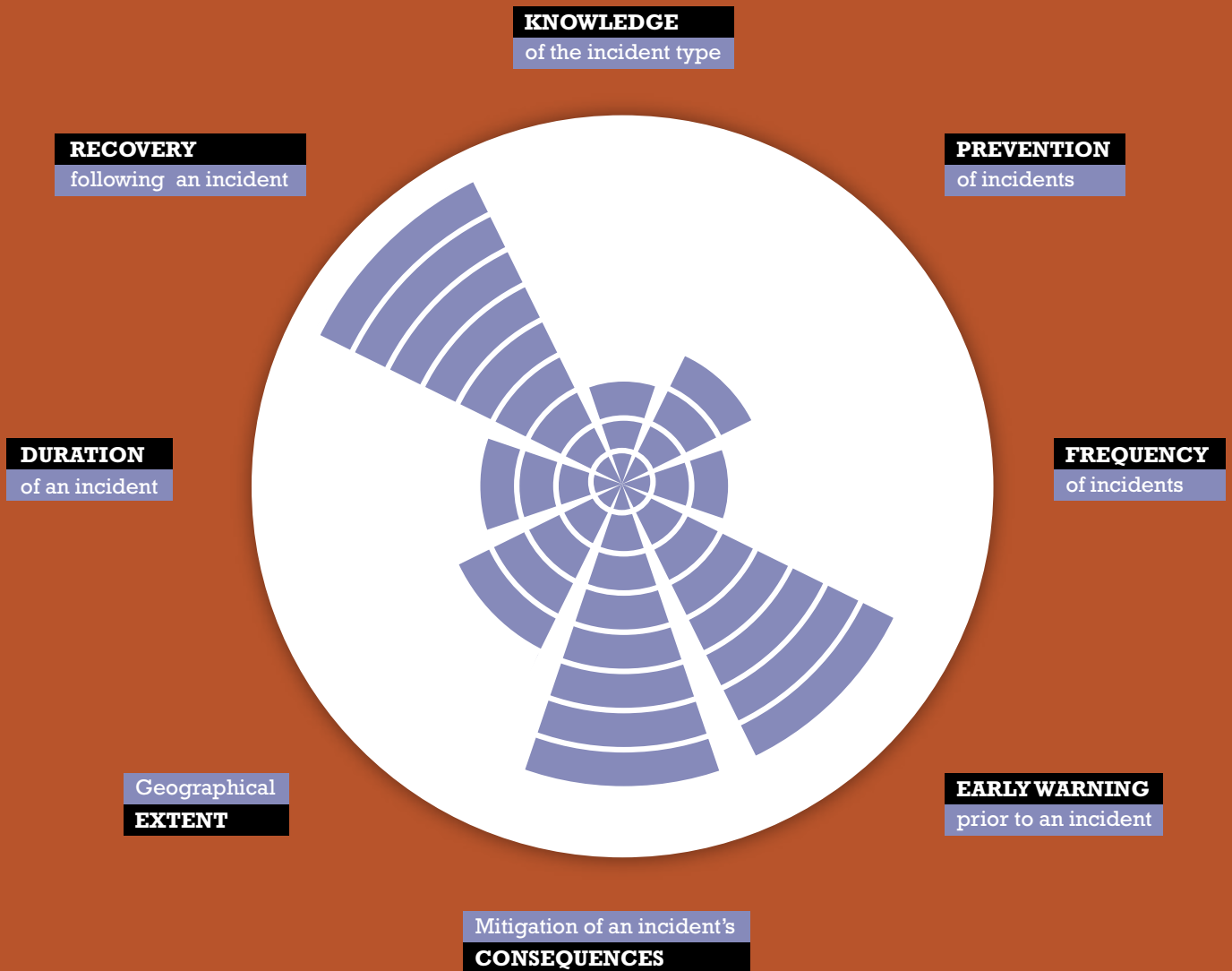
Depending on the complexity and extent of the accident, the accident site may also pose many dangers to the personnel sent to deal with it, e.g. the risk of secondary explosions, uncontrollable spread of fire, sudden collapses, unexpected releases of chemical agents, etc. The necessary precautions with regard to the safety of the personnel dealing with the accident can therefore have an effect on how emergency efforts are carried out.

Personal injury can also result if people do not follow the instructions provided by the authorities about staying indoors, closing windows, maintaining safety distances, etc.

As well as the immediate personal dangers, accidents involving chemical agents can also be a

Challenge Pattern:
Accidents Involving Chemical Agents

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Accidents involving chemical agents usually occur suddenly and without warning. If people cannot be evacuated in time, and/or it is not possible to prevent discharges to the environment and surrounding area, the consequences of an incident can be considerable. Cleaning up areas that have been in contact with certain chemical agents can be a long and expensive process. While minor accidents with chemical agents occur frequently, accidents on an industrial scale occur only rarely in Denmark.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

longer term hazard. The consequences of discharges to the environment – e.g. for animals, plants, land, lakes, streams, and groundwater – can potentially be vast, and in some cases it takes several years to restore the environment in a contaminated area. Apart from the consequences for life, health, and the environment, accidents involving hazardous substances can also generate major economic costs.

If an accident is due to a fire, an explosion, or a collision, extensive material damage may result to nearby buildings, vehicles, and infrastructure. There may also be major expenses associated with the clear-up and/or decontamination operation, as well as the subsequent removal of contaminated water and soil. If it proves necessary to rehouse affected members of the public, this can be a long and costly process, too.

Finally, accidents involving chemical agents can have an impact on the availability of some critical societal functions. For example, if hazardous chemicals penetrate the groundwater, the drinking water supply in a local area may be seriously affected, while in the transport sector it may be necessary to divert traffic for a period of time. This can prove inconvenient, particularly

because many industrial operations are located close to traffic hubs.

The nature and extent of the possible consequences depend very much on the situation and are affected, among other things, by:

- The quantity, toxicity, harmful environmental effects, location, and properties of the chemical agents in terms of the fire and explosion hazard posed.
- The extent and reliability of the safety arrangements that are in place, e.g. those resulting from legal requirements regarding preventive measures.
- The weather conditions at the time of the accident, including wind strength, wind direction, and volume of precipitation.
- The number of people in the immediate vicinity of the accident, and the distance to the nearest homes and businesses.
- The vulnerability to contamination of the surrounding environment, including the adaptability of the ecosystem.
- The effectiveness of warnings, emergency life-saving efforts, shielding and enforcement of safety distances, cleaning and decontamination, as well as the subsequent clean-up.

Consequence Pattern:

Accidents Involving Chemical Agents

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Examples

In terms of the extent of material damage, the biggest industrial accident of recent times in Denmark was the fire and explosion at the N.P. Johnsen Fireworks Factory at Seest near Kolding on 3 November 2004. It is presumed that the accident began when, during routine emptying of a 40-foot container, an employee dropped a box containing rockets, which then ignited. The fire spread rapidly to the rest of the fireworks in the container, as well as to fireworks on pallets outside and in a neighbouring open container.

Around an hour and a half after the fire had started, there was an explosion in one of the containers. One firefighter lost his life in the explosion, while several other people were injured.
The explosion caused the fire to spread to a nearby warehouse storing more than 800 tonnes of fireworks. Three subsequent explosions then occurred in the factory area, upon which the entire factory and buildings in the vicinity burst into flames.

Around 800 people took part in fighting the fire, including around 350 firefighters, 150 police officers and 300 members of the Danish Home Guard. Among those living in the area, there were 17 minor injuries. Around 2,000 people from 760 homes were evacuated, along with employees of companies in the immediate vicinity. The premises of twelve companies were subsequently razed to the ground and there was damage to around 350 detached homes, many of which burned down entirely or were rendered uninhabitable.

One of the most serious transport accidents in Denmark in recent times involving hazardous substances occurred on 25 September 1992, when a cargo train collided with a stationary passenger train at Næstved station. The accident occurred early in the morning, at a time when the passenger train was empty, although a number of carriages were derailed and damaged. When a release of liquid was first noticed, the immediate assumption was that it was simply diesel from a tank. However, it then emerged that, in addition to the oil, liquid was pouring from an overturned tank wagon containing more than 60 m^3 of acrylonitries. Acrylonitrile is a highly toxic and flammable chemical that can also form explosive mixtures in contact with normal air. It is toxic to people both by contact with the skin and by inhalation of the vapour.In the event of a fire it can produce an even more toxic substance, hydrogen cyanide. The area surrounding the overturned tank wagon was therefore sealed off and covered in foam to prevent ignition and poisoning.

A total of 400–600 litres of acrylonitrile spilled onto the ground. The accident initially led to 52 people being admitted to hospital. The clean-up of the ground around the tracks and subsequent environmental clean-up required an exceptionally long time. Many thousand litres of contaminated water were collected daily over a long period, and a total of over 300 m^3 of soil contaminated with acrylonitrile and 155 m^3 of soil contaminated with oil were removed. The environmental clean-up was not complete until November 1996, more than four years after the accident.

Key Actors

- **Danish Emergency Management Agency (DEMA)**
- **Danish National Police**
- **Danish Environmental Protection Agency**
- **Danish Veterinary and Food Administration**

- **Danish Health Authority**
- **Danish Patient Safety Authority**
- **Danish Transport, Construction and Housing Authority**
- **Danish Regions**
- **Municipalities**

Fire in an industrial property in the Port of Fredericia. Large quantities of nitrogen and palm oil spilled into the Lillebælt strait during the accident in February 2016. Image: SCANPIX

What if…

…a tank containing dimethyl ether were to leak unobserved in a cargo terminal? The substance, which is used in industrial and research contexts, is not very toxic, but it is readily ignitable and constitutes a fire hazard.

Shortly afterwards, the tank explodes. A lorry driver and several of the employees at the terminal are killed in the pressure wave, and the explosion causes further damage to other chemical storage installations, some of which begin to leak gases and liquids.

It is unclear how many storage installations are affected and exactly what substances have leaked. However, employees from the terminal and from a neighbouring company, who have come to the rescue at the site, begin to show signs of poisoning.

At the same time, the wind is blowing in the direction of the nearby town centre…

9.

Maritime Accidents

Fire on the Deepwater Horizon drilling rig in the Mexican Gulf in 2010. With a release of 4.9 million barrels of oil, the incident is one of the worst ever environmental disasters. Image: US Coast Guard

September 1994
On the night of 28 September, the passenger ferry MS Estonia sailed into a bad storm in the Baltic Sea on its way from Tallinn to Stockholm. There were strong winds and very high waves. When the force of the waves tore off first the bow visor and then the ramp to the ferry's vehicle deck, the ship quickly took on water.

Less than an hour later, the ship had sunk.

Difficulties issuing the emergency signal and indicating the ship's position delayed the rescue effort. 852 of the total of 989 people on board died. The loss of the MS Estonia is one of Scandinavia's worst maritime disasters in the 20th century.

Characteristics

In this context, the term 'maritime accidents' covers all major incidents at sea that lead to the loss of life, injury to people, or such extensive damage to property or the environment that a significant coordinated rescue or clean-up effort is required on part of the authorities. Such incidents will often involve vessels used for transporting goods or people, fishing vessels, and offshore installations. In terms of the rescue effort, an aeroplane or helicopter crash over the sea will also constitute a 'maritime accident'.

There are particular challenges associated with accidents that occur at sea. Reaction times may be longer due to the long distances from land, because the options for action available are easily limited by severe weather conditions, and because evacuating a large number of people is both difficult and dangerous in itself.

Groundings, collisions, and fires are some of the obvious hazards that particularly apply to shipping. Accidents that involve extensive pollution of the marine environment are also a particular risk.

Large ships often sail with significant quantities of fuel on board – so-called 'bunker oil'. This means that oil pollution is a potential consequence even in accidents that do not involve the transport of oil as cargo, per se. In addition to this, there is the actual extraction and transport of oil, which can cause pollution accidents on a much larger scale. Other chemicals, too, are transported by sea, but

generally in smaller quantities. Even so, as many chemical agents are much more harmful to health and the marine environment than is the case for oil, a chemical release of small quantity may cause major problems in inner waters.

Risk Outline

Occurrence

Denmark is a notable maritime nation by any standard. Despite the country's modest size, it is estimated that Danish shipping companies account for the transport of ten per cent of the world's total trade. While the size of the Danish merchant fleet approaches 700 ships, only a few of these vessels regularly enter Danish ports. By contrast, the waters around Denmark are heavily trafficked by ships of other nationalities. This is due in particular to the country's location next to the most important navigable access route to the Baltic Sea and its many important ports.

Each year, around 36,000 commercial vessels pass through the Øresund strait that runs between Denmark and Sweden, while some 27,000 pass through the Great Belt strait between the islands of Funen and Zealand. Of these, around 5,500 are tankers, which typically transport crude oil. In a typical year, more than 500,000 ships enter Danish commercial ports. At the same time, a defining feature of the Kattegat sea is the narrow passages and limited sailing routes through the Great Belt and Øresund straits. This leads to a particularly high traffic density in certain waters.

In addition to cargo transport and industrial fish-ing, leisure sailing, and ferry traffic are also part of the day-to-day marine traffic. There are scheduled passengers ferry services between Denmark and Norway, Sweden and Germany, as well as a number of domestic ferry routes, prima-rily connecting the many smaller islands to the mainland. During 2015, almost 300 cruise ships also passed through the Great Belt, with an average of over 3,000 passengers per ship. Cruise

ship traffic has been increasing sharply in recent years, a trend that is expected to continue. Since 1972, several operators have been extracting oil and gas from Danish fields in the North Sea.
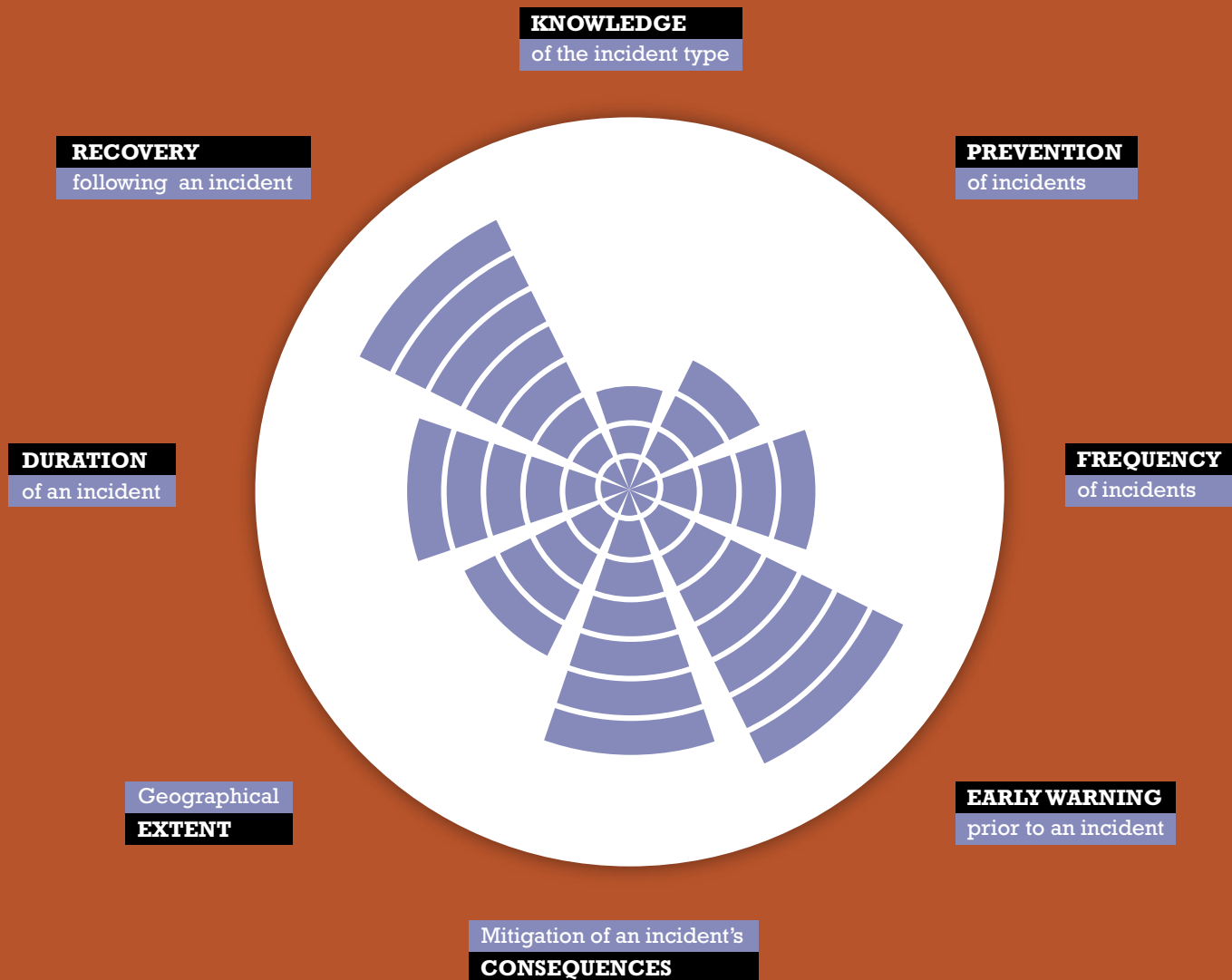
Since then, there has been a marked increase in production, and since 1997 Denmark has been self-sufficient in energy and a net exporter of both oil and gas. There are 17 oil fields in the Danish sector of the North Sea, with a total of 48 permanent platforms actively extracting oil. In addition to this, there are a number of mobile platforms that are predominantly used for research purposes and test drilling. The number of these platforms varies between 10 to 15 units.

A number of other countries – including the United Kingdom, Norway, and the Netherlands – also have active oil fields in the North Sea close to the Danish fields. The total number of offshore installations that could cause an environmental disaster in Danish waters or along the Danish coastline thus far exceeds those active in the Danish fields.

As well as the oil being extracted from the North Sea, large volumes are shipped from the harbour terminal at Primorsk, north-west of Saint Petersburg. The oil arrives in Danish waters aboard tankers with a capacity of up to 150,000 tonnes, as larger tankers are unable to sail through the narrow and shallow Danish straits. In the Kattegat, once the ships have passed the Great Belt or Øresund, the oil is reloaded onto socalled supertankers, which are larger (with a capacity exceed- ing 250,000 tonnes) and more costeffective on the world's major oceans. Reloading takes place directly at sea, from ship to ship.

Danish search and rescue services perform around 350 marine rescue operations each year. Most of these are triggered by minor incidents. The frequency of large, serious maritime incidents in Danish waters has been low during the past two decades, both in terms of accidents that are a danger to human life and accidents involving pollution. This is due to a generally increased focus on safety, better organisation of proactive

Challenge Pattern:

Maritime Accidents

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

There is a particular urgency to accidents that occur at sea. For many types of maritime accidents, it is not possible to issue warnings before they occur, and there is always an immediate danger of drowning or hypothermia present when they do. Incidents involving oil or chemical spillages can have very longlasting consequences for marine and coastal environments. Cleaning up requires a complex and long-standing effort.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

assistance, and significantly improved systems for monitoring maritime traffic. Despite the low incidence, however, the risk of major maritime accidents remains.

Maritime accidents can occur due to human error, technical errors, external causes, or any combination of these. Human error includes direct operational error – for example, the conscious or unconscious neglect of safety procedures or lack of attention to danger. Human error can also be of a more systemic nature, such as lack of maintenance over a long period of time, an inadequate safety culture, or conscious cutbacks on staffing levels or facilities.

Technical errors may arise in equipment or systems, for example wear and tear that has gone unnoticed, or the spontaneous failure of IT, communications, and navigation systems. External causes are causes of accidents that are due neither to the material nor the people who operate it. One example is extreme weather. In the North Sea, in particular, weather conditions are changeable and often violent. A wilful intent to cause harm to people or property, such as arson or sabotage, can also be considered as an ' external cause'.

Consequences

Maritime accidents always place the life and health of those involved in imminent danger. This may be a direct consequence of the specific accident – for example, an explosion, collision, or fire – or a consequence of the vulnerability that comes from being at sea. The danger of drowning or of hypothermia poses a constant risk to life, particularly in cold waters such as those around Denmark and even more so in the winter months. Thus, even minor incidents, when they occur at sea, can have very serious consequences, such as debilitating brain damage and death. For this reason, in the case of accidents on ferries and cruise liners, many people may be in danger even after evacuation efforts have been initiated.

When large ships are wrecked in inner waters and harbour areas, some degree of damage to the infrastructure may ensue. The collision of a Finnish freight ship with the railway bridge across

Limfjoden near Aalborg in 2012 led to rail services to Vendsyssel being suspended for more than two years until the leaf of the bridge had been replaced and repairs to the bridge finally completed. Had the timing of the collision been more unfortunate, the incident could also have led to a serious rail accident. Collisions between ships and Danish bridges typically occur 10–20 times a year, though usually without resulting in any structural damage to the bridge.

Accidents involving the release of oil or chemicals are particularly difficult to contain and manage when they occur at sea. Depending on the weather conditions, spilt crude oil and refined oil products can spread over large areas of the sea's surface and be dissipated over large distances. Oil and chemical pollution is damaging to both the marine and the coastal environments and has extraordinarily serious consequences if it affects vulnerable areas, or areas important to wildlife and nature.

With an oil spillage, an attempt is normally made to contain the oil and suck it up into tanks or containers. Chemical spillages are generally more difficult to deal with, as chemicals vary greatly. It will not be possible to remove sinking and water-soluble chemicals, while some chemicals react with water and form toxic and corrosive gases. Compared to the number of oil shipments, there are only few shipments of chemicals in Danish waters. There is, however, also more limited experience of handling the multi-faceted challenges that a maritime chemical spill would present.

If oil pollution affects a stretch of coastline, it can cause great damage to animal and plant life here, too. Birds are particularly vulnerable, even where only small volumes of oil are involved.

At the same time, beach areas are rendered unusable for recreational purposes, causing great harm to the tourist industry. Revenue from the tourism industry in Denmark amounts to almost DKK 100 billion a year, with coastal and wildlife tourism accounting for almost half of this. The local economies of several smaller coastal communities are also highly dependent on income from seasonal tourism. An oil pollution incident

Consequence Pattern:

Maritime Accidents

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

occurring immediately before or during the peak tourism season could thus have a major economic impact.

Collecting oil, whether on land or at sea, is a very costly, labour-intensive, and protracted task that is nonetheless necessary, as it can take decades before the oil is broken down by nature itself and thus no longer able to damage the ecosystem. Depending on where the spillage takes place, and the duration of the control and clean-up work, maritime traffic may also be disrupted as a result of closures to sailing routes or harbours. Oil and chemical spillages can also affect fishing and marine aquaculture. In addition to production losses, food safety may be jeopardised and require an extensive effort by the authorities. The total financial cost of dealing with pollution to the marine and coastal environment can therefore be considerable.

Examples

On the night of 7 April 1990, a fire broke out on the passenger ferry MS Scandinavian Star. The ferry was in the Skagerrak en route from Oslo to Frederikshavn. Of the 482 on board, 159 died as a result of the fire, with most deaths being due to carbon monoxide poisoning or the inhalation of toxic smoke while the people were asleep in the ship's cabins. It was not possible to extinguish the fire completely until the ferry had been towed to the Swedish coastal town of Lysekil. Subsequent investigations showed that the fire had been started deliberately.

Early one morning in January 1993, the ferry Jan Heweliusz capsized and sank. The ferry was operating a scheduled service between Ystad in Sweden and Swinoujscie in Poland. There were 63 passengers and crew on board, of whom 55 lost their lives. The ferry, which had previously been involved in several accidents, sailed despite a warning of hurricane force winds in the Baltic Sea.

On the evening of Thursday 3 March 2005, the cargo ship M/V Karen Danielsen set a wrong course on its way from Svendborg to Finland. At 7:12 pm, the ship collided with the western part of the Storebælt Bridge, becoming wedged under the low-level bridge. The entire wheelhouse of the ship was bent astern in the collision, killing the Chief Officer – the only one of the ten crew members on the bridge at the time. Two of the ship's cranes were knocked overboard and a fire broke out. The bridge connection was closed for around five hours until technicians were able to ascertain that the collision had caused visible but not structural damage to the construction.

On 6 July 1988, the Piper Alpha oil and gas platform exploded in the British sector of the North Sea, killing 167 people. It is thought that the explosion was caused by the use of the wrong pump during maintenance work. Despite the explosion and fire, deficiencies in the safety procedures meant that oil and gas were still being sent to the Piper Alpha from adjacent platforms. This supply caused the gas pipes themselves to explode.
Flames rose almost 100 metres into the air, and most of the platform collapsed into the sea. The accident led to the implementation of various technical and safety-related changes in the industry.

On 20 April 2010, an explosion occurred on the Deepwater Horizon drilling rig in the Mexican Gulf. Eleven people were killed. It proved impossible to extinguish the resulting fire, and on 22 April the platform sank, causing the well on the seabed to start leaking oil directly into the sea. It was not until 15 July 2010 that it was possible to stop the oil spillage, by which time an estimated 4.9 million barrels of oil had been discharged into the sea. The accident led to one of the worst ever environmental disasters. The oil, and the chemicals used in an attempt to remove it, led to significant loss of animal and plant life, and oil was still washing ashore several years after the disaster.

The biggest oil pollution incident to date in Danish waters occurred on 29 March 2001, when the oil tanker Baltic Carrier collided with the

cargo ship Tern at Grønsund in the waters south-east of Falster. The collision resulted in the discharge of around 2,350 tonnes of fuel oil from the Baltic Carrier's total load of around 33,000 tonnes.

Difficult weather conditions complicated the collection of oil in the open sea, and a lot of oil flowed into the east-facing coasts of Møn and Falster as well as into the Grønsund strait. The

clean-up work created unexpectedly large volumes of waste, which was initially difficult to store as there were no plans in place for storage on land. After a two-week effort, around 3,950 tonnes of oil and oil-contaminated material had been collected. Grønsund is an important breeding ground for birds, and it is estimated that up to 20,000 birds died as a result of the pollution.

Key Actors

- **Danish Maritime Authority**
- **Defence Command Denmark**
- **Danish Energy Agency**
- **Danish Environmental Protection Agency**
- **Danish Veterinary and Food Administration**
- **Danish Maritime Accident Investigation Board**

- **Danish Emergency Management Agency (DEMA)**
- **Danish Regions**
- **Municipalities**
- **Danish Working Environment Authority**
- **Danish National Police**

What if…

…a violent explosion were to occur on an oil installation in the Danish sector of the North Sea?
The pressure wave and subsequent fire places the lives of the employees in acute danger, and even those who are evacuated into life rafts remain exposed in the open sea.

The continued heat build-up weakens the structure of the drilling rig, leading to its partial collapse and a large, continuous oil spillage as a result.

A north-westerly wind spreads the oil over a large area, with a course towards Danish as well as the German and Dutch coasts…

The picture shows the cruise ship Costa Concordia, wrecked off Italy in 2012. Accidents with cruise ships constitute a danger to the lives and health of large numbers of people, even if the accident occurs close to the coast. More and more cruise ships are entering Danish ports, and these may sail with up to several thousand passengers on board. Image: SCANPIX
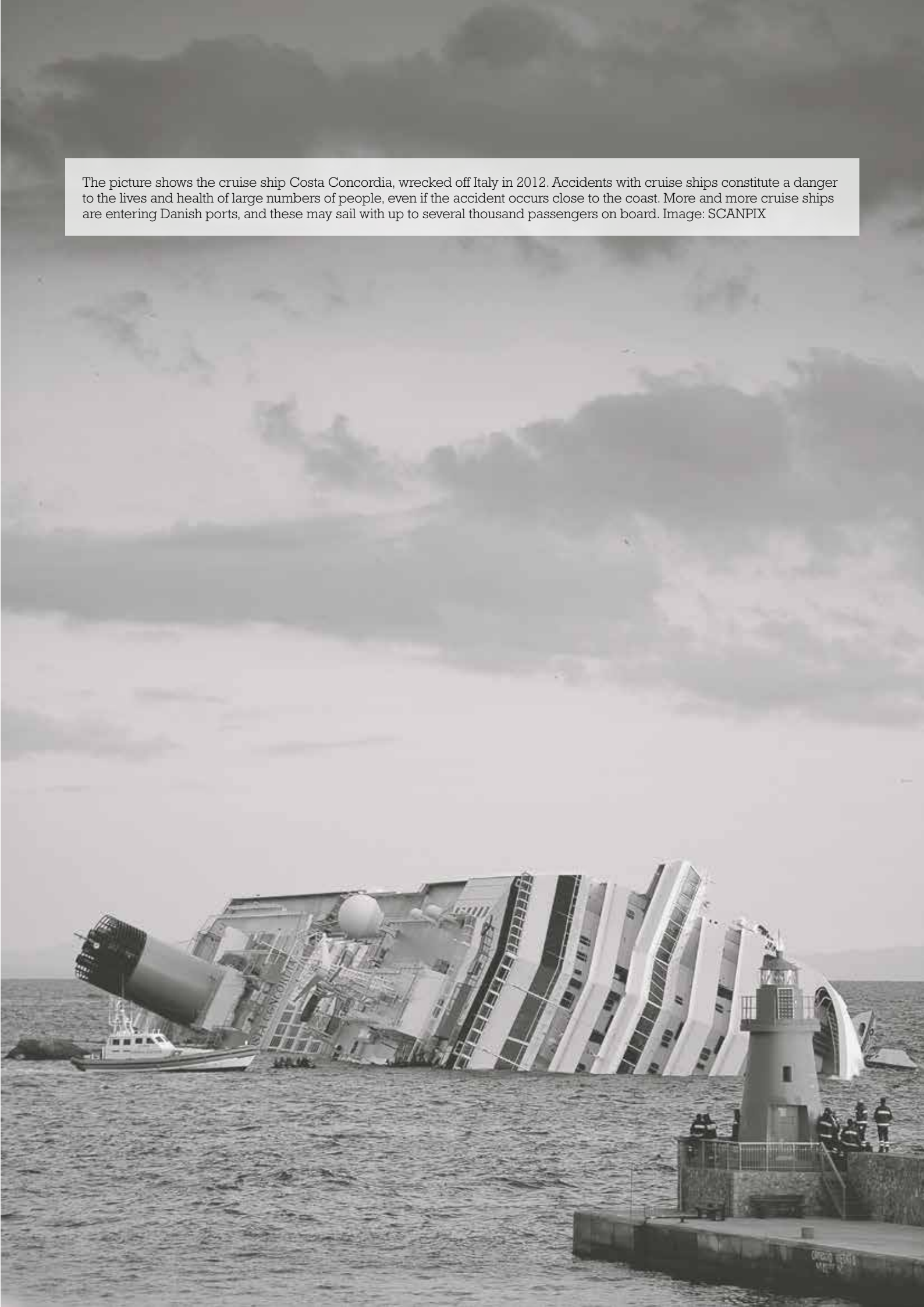
10.

Transport Accidents

In addition to being a fatal to those on board, a plane crash can also be of great danger to people on the ground. In built-up areas, in particular, a plane crash could also cause significant damage to buildings and infrastructure. The picture shows an aeroplane that performed an emergency landing in the Hudson River in New York in January 2009 after both engines stalled over the city. Image: SCANPIX

April 1988
On 25 April 1988, an intercity train crashed outside Sorø on its way from Jutland to Copenhagen. Several carriages were derailed and overturned on the tracks shortly before the train reached Sorø station. Eight people were killed and 72 injured.

Investigations revealed the cause of the accident to be excessive speed. The train was travelling at 120 km/h on a section with a 80 km/h speed limit.

The incident is the worst rail accident in Denmark in recent times.

Characteristics

The term 'transport accidents' covers accidents with vehicles that involve the physical movement of people or goods, as well as accidents relating to transport infrastructure and its management. Transport accidents occurring at sea are not included in this incident type. Rather, these are treated as a separate incident type in the chapter entitled 'Maritime Accidents'.

The potential causes of transport accidents can essentially be divided into human error, technical errors, and external causes, although accidents often involve a combination of more than one type of cause. Human error includes direct operator error – for example, the conscious or unconscious neglect of safety procedures or lack of attention. Human error can also be a systemic issue, such as an inadequate safety culture, lack of auditing, or

conscious cutbacks on staff or facilities. Technical errors can occur in the vehicles themselves, as well as in the systems used to control and monitor these. Examples of this are material failure, short circuits, computer errors, and IT breakdowns. External risks relate to conditions or events that include various weather phenomena, as well as intentional acts such as vandalism, deliberate sabotage, cyber attacks, or terrorism.

Transport accidents in the aviation sector may occur while planes and other aircraft are in the air, while taxiing, or on the runways at airports. The greatest risk potential is related to crashes involving large passenger aircraft. Typically, crashes occur on take-off and landing, although they can also occur in mid-flight. Accidents may result from collisions between planes,

helicopters, or drones, or they may be caused by engine faults, navigation errors, or other technical faults.

Accidents may also result from inadvertent human error, as well as deliberate acts conducted, for example, by a mentally unstable individual. Aircraft generally carry a great deal of fuel, which entails an increased risk of fire or explosion in the event of a collision. When aircraft crash over land, the victims may not necessarily be limited to the passengers and crew, as fragments of wreckage can kill or injure people on the ground as well as lead to extensive damage to buildings etc.

Transport accidents in the land transport sector may occur on railway lines, roads, and their associated infrastructure, such as bridges, tunnels, stations, bus and tram stops, freight centres, etc. The biggest risks relate to the rail sector, particularly in term of crashes involving passenger trains (Copenhagen's Metro and S-train system, regional, and long distance rail services), although most accidents with major consequences occur on the roads. Collisions between trains running on the same track, or crossing tracks, can occur due to misconduct or negligence in the remote control centre or if a train driver misses a signal, deliberately or as a result of inattentiveness. In addition, damaged track systems and signal boxes can lead to a train becoming derailed, either on an open section of track or at a location where it may collide with other trains, buildings, bridges, or other infrastructure elements. Material faults on the trains themselves or on the track (e.g. on the rails and points systems) can have the same consequences. There is also the possibility of trains colliding with maintenance vehicles and machines left on or close to the rails. Weather events, such as extreme rainfall or strong storms and hurricanes, can wash away material beneath the rails or cause trees to fall onto the line and thereby derail trains. In accidents of this type, the victims may not necessarily be limited to passengers and train personnel, but also include anyone in the immediate vicinity of the accident site.

Collisions between trains and other vehicles at level crossings normally have the worst effect on the latter. However, depending on the speed at which the train is travelling and the weight of the other vehicle, a collision could, in the worst case, derail and overturn a train.

In the road sector, accidents occur as a result of collisions between buses, lorries, cars, etc., as well as where road works are taking place. Minor road traffic accidents are common, but in terms of the NRP they are also the least serious type of transport accident. However, in some cases the consequences can be extensive – for example, in accidents involving buses carrying large numbers of passengers, or mass collisions on motorways, particularly if these occur in tunnels or on bridges.

Risk Outline

Occurrence

Every day, an average of between 25,000 and 30,000 flights are completed in Europe. Statistically, air travel is the safest form of transport – significantly safer than travel by rail, bus and, in particular, private car. This is partly due to a high level of safety culture, the international standardisation of rules, and a good coordination and management of air traffic. Major air accidents with fatal outcomes have occurred only rarely in Denmark. The most recent incident occurred in 1989, when a Norwegian charter plane fell into the Skagerrak sea, killing all 55 people on board. Globally, the number of fatal crashes involving large passenger aircraft continues to fall. In 2015 such crashes accounted for just six out of 92 plane crashes, the lowest level in five years. In the same year, the overall crash rate was 2.8 per one million flights, which is the lowest recorded level globally over the past five years. Generally, the rate has remained very stable over the past ten years.

During the same period, there has been a significant growth in the number of flights worldwide. This trend equally applies to Denmark, with for example Copenhagen Airport registering a record 26.6 million passengers in 2015. The substantial majority of fatal accidents involve smaller private aircraft, where the number of fatalities per accident is relatively low.

There have been a number of fatal rail accidents in Denmark during the past few decades. These include small-scale collisions of trains with cars and other vehicles on level crossings, derailments, and collisions between trains. If we ignore accidents at level crossings, there has been only one fatal train collision since 2005. No fatal derailments have occurred during this period, though a number of accidents have led to serious injury. Rail traffic systems generally operate with a high level of safety. Greater focus on maintenance and inspections in recent times has decreased the risk of serious rail accidents compared to previously. In addition to this, there has been more focus on technical initiatives and new systems such as CBTC (Communications-Based Train Control), ATC (Automatic Train Control), and the 'HKT' Speed Check and Train Stop system, which have either already been implemented or are about to be. The number of level crossings is being reduced throughout the country and work is in progress on some more recent measures involving the installation of new rails and signalling systems etc.

Challenge Pattern:

Transport Accidents

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Major transport accidents are rare occurrences in Denmark, thanks in part to extensive preventive work and a good safety culture. However, faults of various kinds can arise without warning and lead to serious consequences. Transport accidents are local phenomena. However, if they occur close to traffic hubs or bottlenecks, they can affect accessibility in a fairly large area and entail a costly and long-lasting restoration effort for the infrastructure.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

The highest number of road traffic fatalities on the Danish road network was 1,213 in 1971. Since then, the figure has fallen significantly. In 2015, there were 178 fatalities, which occurred in 172 separate accidents. This figure includes many smaller isolated incidents involving few fatalities or injuries, which are dealt with locally. Road traffic accidents involving more than two fatalities are infrequent occurrences on the Danish road network. Speed limits, speed checks, traffic calming measures, better signage, and – not least – an increased safety level in buses, lorries, and cars have all had a positive effect on accident trends. The current trend is for more people and goods to be transported by bus and lorry than previously. All other things being equal, this increase in the number of buses and lorries on the road network increases the risk of more people being killed or injured per accident.

The basis of risk for transport accidents may change over the coming years, in part due to the expected increase in the number of airborne drones for various purposes, as well as to the increased use of driving support systems in vehicles on the road network.

Consequences

When high volumes of people are being transported, an accident can lead to a large number of fatalities and injuries. Aircraft and trains are capable of transporting more people than are cars and buses, which therefore also means more potential victims. In complex transport accidents, the extent of the accident will often be unclear in the initial deployment phase. The accident site may also pose many dangers to the personnel involved in the rescue effort.

Furthermore, major transport accidents can cause extensive material damage, both to the vehicles involved and the surrounding infrastructure and buildings, which may have been hit by the vehicles involved or by fragments of wreckage, e.g. from a plane crash, train derailment, or collision.

As well as causing personal injury and material damage, transport accidents can also have environmental consequences in the form of contamination. Transport accidents that cause the release of hazardous substances can have serious consequences for people's lives, health, and property, as well as for the environment. However, transport accidents involving hazardous products are not dealt with under this incident type. Instead, they are discussed in Chapter Eight on 'Accidents Involving Chemical Agents' and in Chapter Nine on 'Maritime Accidents'.

Repair work and clean-up following transport accidents can be highly expensive. Typically, too, major costs will be involved if the damage necessitates lengthy traffic diversions or the organisation of alternative transport solutions. Transport accidents can furthermore impose a significant financial burden on the operating company if operations are suspended for a lengthy period. Shutdowns may result from damage to the infrastructure or safety considerations – for example, where certain types of aircraft or train must undergo rigorous testing for faults before being approved for use again.

Finally, there may be major derived consequences for the maintenance of vital societal functions if a major transport accident leads to a lengthy shutdown of an airport, port, sailing route, bridge, tunnel, or station, or an important stretch of railway or motorway. A suspension of road and rail traffic over the permanent links across the Great Belt or Øresund straits, for example, would affect large sections of the population and industry, and the situation would gain an international dimension due to the negative impact on transport between the rest of Scandinavia and the continent. Similar effects could occur if a major air accident led to the temporary closure of, in particular, Copenhagen Airport, which acts as a hub for the whole of Scandinavia.

Consequence Pattern:

Transport Accidents

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Examples

The worst plane crash in Danish territories occurred on 8 September 1989, when a privately chartered plane full of passengers from the Norwegian shipping company Wilhelmsen Line was en route from Oslo to Hamburg. Shortly after the plane had entered Danish airspace, it crashed into the sea 18 km north of Hirtshals. The crash was caused by spare parts in the tail of the aircraft failing to meet the strength and hardness requirements, causing the tail to break apart. All 55 people on board were killed.

In terms of scheduled air traffic involving Danish commercial interests, the worst air accident in the history of Scandinavian Airlines occurred at Linate airport outside Milan on 8 October 2001. As a scheduled SAS flight was taking off, a small German-registered Cessna jet ran into the side of the airliner, which then careered into a luggage hangar. All 110 people on board the SAS flight died, including 16 Danish passengers and two Danish crew members, along with four people on the Cessna jet and four people in the luggage hangar.

On 27 February 2001, a double-decker bus ran into the Knippelsbro Bridge in Copenhagen, after the driver had overlooked the warning signs showing the bridge clearance height while driving at excessive speed. The roof of the top deck of the bus was peeled off. The accident resulted in two fatalities and left ten people seriously injured.

On 13 February 2010, a Danish bus containing pupils, parents and staff from an institution in Amager crashed on a German motorway. The accident was caused by excessive speed and hard braking, and it resulted in three fatalities and 13 people injured.

In June 2013, a bus full of Danish business school students collided with a low bridge in a suburb of Munich. Thirty people were injured in the accident. The driver overlooked the warning signs, and the bus became jammed under the bridge.
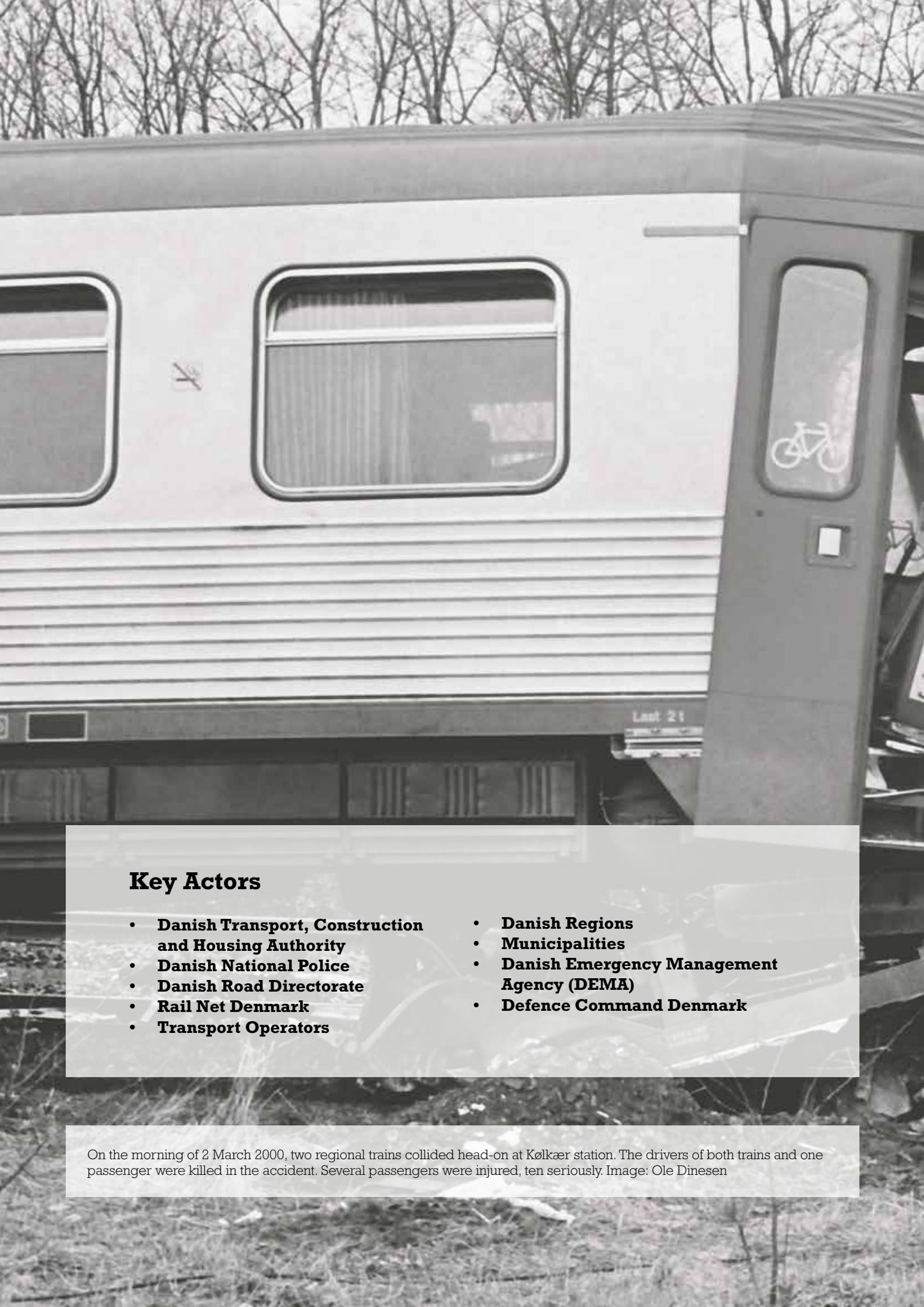
Key Actors

- **Danish Transport, Construction and Housing Authority**
- **Danish National Police**
- **Danish Road Directorate**
- **Rail Net Denmark**
- **Transport Operators**

- **Danish Regions**
- **Municipalities**
- **Danish Emergency Management Agency (DEMA)**
- **Defence Command Denmark**

On the morning of 2 March 2000, two regional trains collided head-on at Kølkær station. The drivers of both trains and one passenger were killed in the accident. Several passengers were injured, ten seriously. Image: Ole Dinesen

What if…

…a westward-bound intercity train were to be hit by iron girders protruding from an oncoming freight train? The left-hand side of the intercity train is torn apart in the accident. The train is derailed in the middle of a section of track that is difficult to access. In the derailment, the train tears down an overhead line support, leaving it lying across the tracks.

Several passengers are either hit directly by the iron girders or severely injured in the derailment. Reaching and transporting heavy rescue equipment to the accident site proves to be a major challenge to the emergency services. Many passengers are either dead or severely injured and trapped. Freeing and treating as many of the injured as possible becomes a race against time…

11.

Cyber Incidents

Cyber attacks can affect anyone who uses, or depends on, IT systems. Attacks can be performed for instance through hacking or malware. Image: Colourbox

December 2015
More than 200,000 households in the region of Ivano-Frankivsk in Ukraine were left without electricity for several hours. This was equivalent to half the households of the area.

It later appeared that a cyber attack conducted using, among other things, the computer malware 'BlackEnergy 3', had affected at least three regional energy suppliers. The malware, which in this case disconnected several electricity substations from the distribution grid, had previously been used to attack state authorities and media companies in Ukraine as well as energy suppliers both within and outside the country.

This incident was a seminal event, as it was the first case in which it could be confirmed that a cyber attack was directly involved in a major power cut.

Characteristics

The term 'cyber incidents' covers incidents in which information technology (IT) plays a significant part. By this, we mean that the incidents always involve software and/or hardware – and often the connections between systems. Cyber incidents can be divided into deliberate actions and technical faults.

Deliberate actions are often called 'cyber attacks'. These are electronic attacks aimed at IT assets such as computers, servers, systems, networks, services, etc., that are directly or indirectly connected to the Internet. There may be episodes in which the Internet is used as a tool to render IT systems unusable, take control of them or force

access to and then, for example, forward, delete, or amend confidential data. Cyber attacks can thus undermine not only accessibility but also the integrity and confidentiality of both data and IT systems. In most cyber attacks, the geographical distance between attacker and victim plays no significant role as the attacks usually take place over the Internet. Perpetrators can therefore operate from anywhere in the world.

Cyber attacks can be carried out in a variety of ways, including hacking and the use of malware. The players who carry out cyber attacks may be individuals, small groups, or large networks of people, or they may be entire states or

statesponsored groups. It is primarily these latter two types of players that are considered capable of conducting attacks advanced enough to require management of the attack at national level. One thing that most cyber attacks have in common, however, is that their complexity makes it difficult to identify the perpetrators precisely.

In the NRP, cyber attacks are divided into three categories:

- 'Cyber espionage' (or 'cyber spying') includes actions designed to obtain data, including sensitive and classified information, intellectual property, commercial plans, etc. Those committing cyber espionage aim to do so in secret, and thus often the victim remains unaware of the actions and their extent. The motive for cyber espionage may be strategic, political, or financial.

- 'Cyber crime' covers actions in which IT is used to commit criminal acts against authorities, members of the public, or private companies. The motive for cyber crime is often financial gain.

- 'Cyber terrorism' includes actions that make use of IT for the purpose of drawing attention to the terror group's cause through violent actions involving physical destruction or murder.

In addition to these deliberate activities, system faults can also generate major IT-related incidents for authorities and companies. For example, these may arise when specially developed IT systems gradually lose their compatibility as newer systems come into use. Such solutions may lack the required adjustments, updates, upgrades, and maintenance, thus making them vulnerable. In a few cases, too, there may be weaknesses in equipment caused by design through inbuilt malware, technically controllable components, vulnerabilities, and erroneous code at the production stage. This may be the result of a deliberate action, but may also occur entirely without the manufacturer's knowledge. There is also the possibility that technical parts of systems may simply break down physically, for example due to a short circuit, heat build-up or defect.

Denmark's national IT security authority is the Centre for Cyber Security (CFCS), which is part of the Danish Defence Intelligence Service (DDIS). The centre's current assessment of the cyber threat level against Denmark can be found on the DDIS website.

Risk Outline

Occurrence

Cyber incidents can affect anyone who uses, or is dependent on, IT equipment and systems. Each day in Denmark, a large number of deliberate actions and system faults occur that lead to minor cyber incidents. Most of these remain at a level that can be managed locally and do not entail any consequences for society as a whole.

However, the extent of the cyber threat from international actions on a worldwide scale – and, therefore, also against Denmark – is constantly on the rise. At the same time, technical developments mean that the threats are in a constant state of change.

The risk of cyber espionage is very high and is ever-present. Recent years have shown a significant rise in the number of attempts to conduct cyber espionage against Denmark and Danish interests. Attacks conducted by foreign states, aimed at our central administration and other authorities, are constantly being identified. There are, for example, attempted attacks against the Ministry of Foreign Affairs of Denmark on an almost daily basis. It is thought that foreign states and state-supported groups are behind these. There is much to indicate that this trend will continue. Furthermore, cyber espionage is committed against Danish companies.

A number of state-supported groups have attacked Danish companies in recent years. The number of attacks is expected to rise, and particularly the larger companies in research-intensive sectors such as high-technology and the medical industry will be subject to an ever increasing number of ever more advanced attacks.

Cyber crime, which includes extortion using ransomware against Danish companies and authorities, has been increasing in both extent and complexity. Criminals are continuously developing

new methods and ever more sophisticated tools with which to commit crimes. Added to this is the phenomenon known as 'crime-as-a-service'. This expression refers to the fact that criminals, who lack the necessary technical skills, nowadays have the option to purchase elsewhere the expertise and software required to commit cyber crime. In this way intent and capacity is more easily joined together. Therefore, a significant increase in cyber crime is expected, both in terms of the number of attacks and the technical level of these attacks.
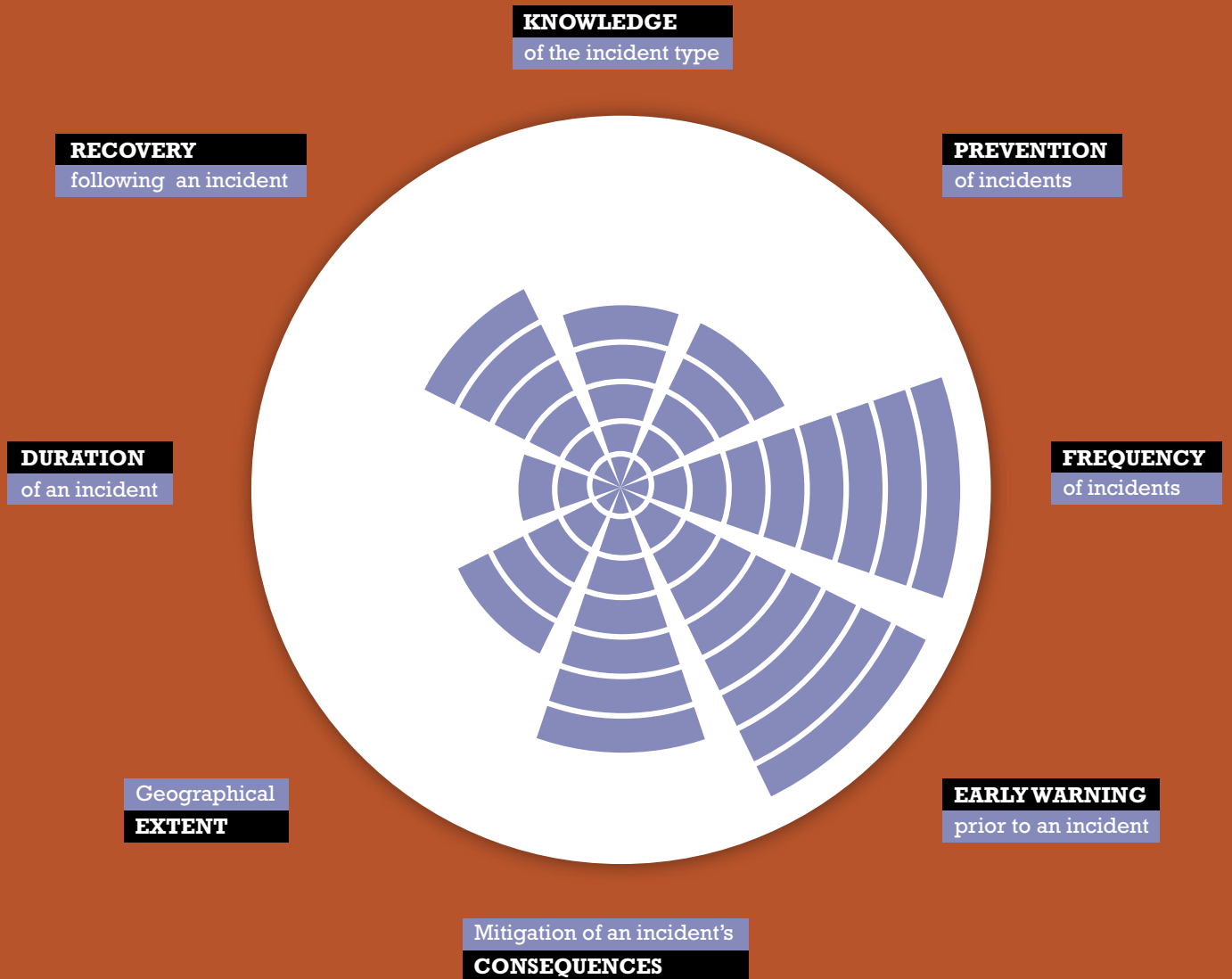
Terror groups have expressed interest in conducting cyber terrorism in the West, including against the infrastructure that supports vital societal functions. There may therefore be anintent to use cyber terrorism to strike against Danish authorities, companies, and organisations. However, so far terror groups have had only a limited capacity to conduct attacks over the Internet. However, the possibility cannot be excluded that, over time, terror groups may acquire cyber capabilities with a view to conducting malicious attacks.

As the use of IT by authorities, companies and organisations increases, so do both the level of vulnerability and the basis for system faults. Tasks and processes that previously were not dependent on IT are increasingly dependent on physical and software-based IT components. This also includes the trend towards connecting more and more everyday electronic components to the Internet – also referred to as the 'Internet of Things'.

While there are certainly a large number of cyber incidents each year in Denmark, it is not possible to document these exhaustively. This is due to the fact that attackers have become better at concealing their activity and identity. Further, not all incidents are reported to the authorities. Therefore, there is a presumably very large dark figure of cyber incidents, that will never become publicly known.

As yet, Denmark has not been affected by a cyber incident that has led to significant, direct, and acute consequences for society. Over the past few years, the Government has enhanced its

Challenge Pattern:

Cyber Incidents

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Cyber incidents, such as deliberate attacks on systems or data, take place every day. The vast majority are foiled by the protective measures in place, but in the case of even minor weaknesses, faults, or inattentiveness, things can go wrong. Similarly, hardware breakdowns and system faults can also occur without warning. The consequences of cyber incidents vary significantly, and a great deal of technical expertise is required to limit them.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

capabilities and added resources to the area, which is an indication of its enhanced awareness of the area and the potentially serious consequences for society. As the threat profile is constantly and rapidly evolving, however, this does not mean that cyber incidents cannot occur.

Consequences

The consequences of cyber incidents depend on many factors, including the length of time for which the incident remains undetected, the data and systems affected, and the possible cascading effects, for example the breakdown of the infrastructure that supports the ability of society to function.

Cyber espionage conducted against authorities by state-run and state-supported groups could mean that players in other countries gain access to information relating, among other things, to matters of foreign and security policy. This can weaken Denmark's position in international negotiations and thus directly damage Danish interests. For companies, cyber espionage can lead to a loss of competitiveness, and even to bankruptcy, if commercial secrets are disclosed and intellectual property rights violated.

Cyber crime can, among other things, have significant economic consequences. The magnitude of the economic losses will be determined by the specific sequence of events and the technical ability of the perpetrators. Losses may for example be sustained through theft, fraud, extortion, or breach of intellectual property rights. Although cyber crime is often aimed at companies, there are several examples of Danish authorities, at both national and municipal level, that have been affected. This can lead to restrictions to the services provided to the public. Public services can also be affected as a knock-on effect of incidents involving private subcontractors that provide IT solutions to the authorities.

The most extreme consequence of cyber terrorism can be loss of life, personal injury, destruction of property, or extensive financial losses.

In many cases, cyber attacks and system faults can – in essence – have similar consequences, with data becoming unavailable or lost, or with entire systems failing. The damage to property and assets, such as computers, networks, servers, data, machines, and industrial systems, can be extensive.

Cyber incidents can affect the infrastructure that supports vital societal functions, such as hospitals or other health care institutions. Cases have been seen in, among other places, Germany and the USA, in which hospitals have been infected with ransomware. Although basic medical treatment could be maintained using traditional paper documentation, capacity was significantly impaired, with patients being discharged prematurely or rejected, while operations and certain forms of treatment had to be postponed. In addition, cyber incidents that affect the control systems of lifts could make it impossible to transport patients to the operating theatres, which – particularly in emergency situations – could prove fatal. High technology medical equipment is increasingly being connected to the Internet to make use of, for example, remote diagnostics. If the equipment is subject to a cyber incident, it may be rendered unusable and thus affect the treatment options available to patients.

The emergency services are increasingly becoming dependent on IT systems. A breakdown of an alarm centre caused by either a system fault or cyber attack would significantly impair the emergency services' capacity to act, particularly if a number of alarm centres were affected at the same time. The overloading of alarm centres may not only occur as a result of malicious intent through denial-of-service attacks. It may also, for example, be the result of inadvertent faults in smartphone apps that independently contact the emergency numbers. There have been cases of serious attacks on alarm centres in the USA. In addition to this, incorrect information from GPS data, digital cartographic materials and situational pictures can cause serious disruptions to emergency management efforts, and at the same

Consequence Pattern:

Cyber Incidents
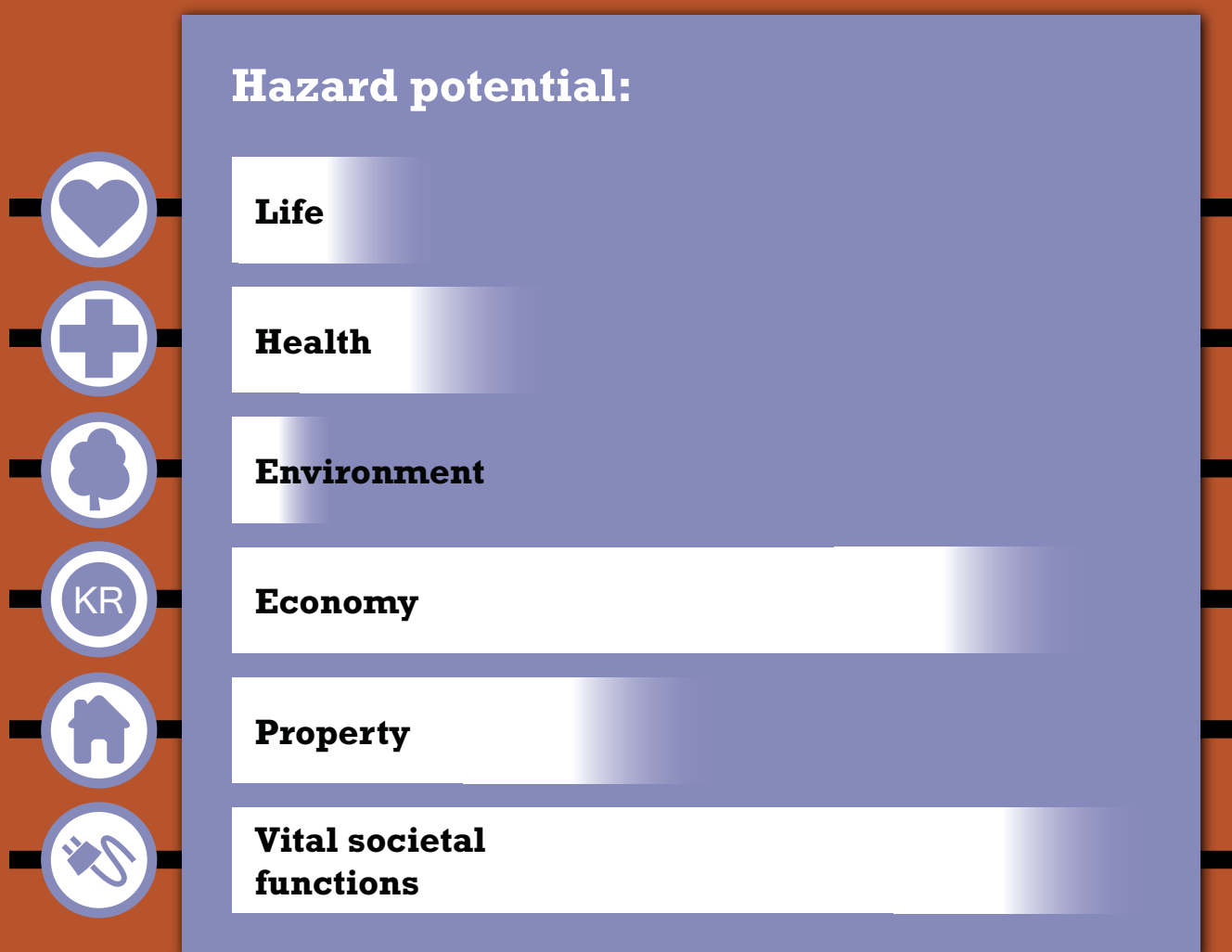
Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

time complicate the work being done by those involved in crisis management, thus jeopardising public safety.

IT systems that support telephone, energy, and water supply services, industrial control systems and the transport infrastructure, are of great importance to vital societal functions. As more and more areas of the infrastructure start to use digital solutions and are connected to the Internet, so their vulnerability and the potential scale of consequences in the event of an attack or breakdown increases. In particular, faults in or attacks on SCADA systems (i.e. industrial control and supervisory systems, which are widely used in a number of sectors) have a potentially far-reaching impact on society.

Power supplies, heat supplies, water supplies, the Internet, mobile phone networks, etc., can be affected in this way by cyber incidents. Rail, shipping, and aviation services may need to be cancelled in whole or in part as a result of serious faults in, or attacks on, control and monitoring systems. Road traffic, too, may be affected if problems occur on systems controlling traffic lights or electronic signage on the roads.

Digital public services and financial transactions may be disrupted or postponed as a result of cyber incidents. The consequences may include disruption of salary payments, pensions, the process of entering records on the Danish central personal and company registers, land and property registration, tax collection, etc. For a time, too, electronic fund and payment transfers, trading in securities, etc., may be unavailable. As an example of this, a cyber attack in 2013 was the reason that the NemID digital login service – a vital part of both public and private sector self-service solutions – was out of action for several hours.

Examples

In the spring of 2007, Estonia was the target of extensive cyber attacks, aimed at public sector

institutions, banks, and media companies. There were significant consequences for vital societal functions, where, for example, banking systems and the country's alarm centre systems were out of action for a time.

The 'Stuxnet' computer worm (a special form of malware) raised the bar for the damage potential cyber attacks during the summer of 2010. The attack has been described as the first known cyber attack aimed at the industrial infrastructure to attain critical significance. The worm infected thousands of computers at an industrial plant in Iran and was particularly sophisticated because it not only stole information but also launched a targeted attack on the plant's SCADA systems. It appears that Stuxnet was aimed at Iran's nuclear power industry and that it penetrated the country's 'Natanz' complex, which houses around 5,000 centrifuges used for enriching uranium. The worm was specially designed to overload the centrifuges by changing their rotation speed, which reportedly resulted in the breakdown of several hundred centrifuges.

A relatively advanced attack affected the Danish Ministry of Industry, Business and Financial Affairs in April 2012. The attackers attempted to reconnoitre the infrastructure behind the various networks under the Ministry, to gain access to usernames and passwords, and to gain access to networks that in turn would provide access to other departments and agencies. In order to halt and deal with the attack, the ministry was forced to close down a number of IT systems. This meant that staff in the department and a number of agencies were temporarily unable to use e-mail or the Intranet.

In 2013, it was discovered that the IT supplier CSC had been affected by an extensive cyber attack. Sensitive data from a number of state authorities was thereby compromised. It was documented, among other things, that some police data had been compromised. Furthermore, in establishing a foothold in the systems, the attackers could have caused the loss or corruption of irreplaceable data.

In the period 2014–15, cyber espionage was

conducted against a Danish IT hosting company and one of its clients. It can be said with great certainty that the attack was conducted by a foreign, state-supported player. For more than a year, the attackers were able to access data, record sound, take screenshots, and register key depressions on the machines affected. It is not possible to say what information was compromised, but it is highly likely that the attackers were able to steal a variety of commercial secrets.

From December 2014 to July 2015, the Ministry of Foreign Affairs of Denmark was under an ATP (Advanced Persistent Threat) attack. The attackers succeeded in infecting a single machine with malware using phishing e-mails. However, one of the Ministry's IT security solutions succeeded in preventing the malware from communicating with the outside world. The attackers did not, therefore, have access to the machine or the data contained on it.

The biggest case of cyber crime to date occurred in 2016. The perpetrators breached the central bank in Bangladesh and stole data that allowed them to perform bank transfers. Using this information, they requested the payment of a total of 951 million dollars from the Bangladesh central bank's account with the Federal Reserve Bank of New York. The incident was discovered while the transfers were in progress and the transactions were suspended. However, the criminals succeeded in removing 81 million dollars, which was then divided among various accounts, mainly belonging to private individuals.

Key Actors

- **Danish Defence Intelligence Service (Centre for Cyber Security)**
- **Danish Security and Intelligence Service**
- **IT suppliers**
- **Danish National Police, including National Cyber Crime Centre**

What if…

…irregularities were discovered in electronic fund and payment transfers?

Several major Danish banks report that their operational headquarters are out of action. Customers of these banks cannot use credit cards, ATMs, mobile payment methods, or online banking.

For several days, most of the population of Denmark can only use cash as a means of payment.
Cash can only be obtained over the counter in the banks. However, the very few branches in the country that store cash are unable to meet the sudden demand.
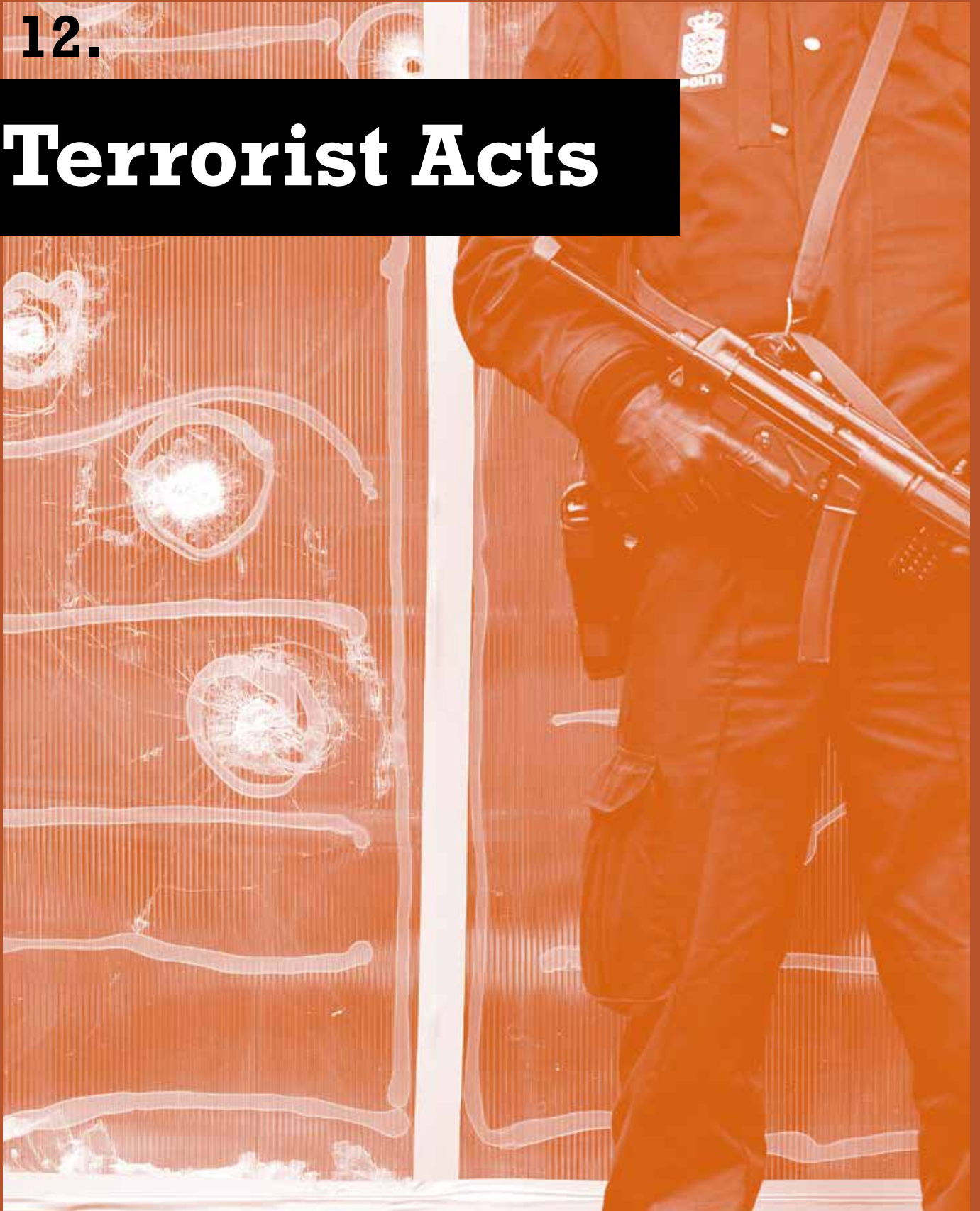
As a result, there are people in all parts of the country who cannot refuel their vehicles, buy tickets for public transport, medicine, food, etc…

Cyber incidents can disrupt or postpone many important and daily functions in society, including electronic fund and payment transfers. Image: Colourbox

12.

Terrorist Acts

The police keep guard on the Krudttønden cultural centre in Copenhagen following the terrorist attack in 2015. Image: SCANPIX

Saturday, 14 February 2015

…at around 3.30 pm, a young man fired numerous shots with an automatic weapon towards the Krudttønden Cultural Centre in Østerbro, Copenhagen. One person died as a result of the shooting, and four police officers were hit either by shots or flying glass.

The perpetrator fled the scene and then turned up past midnight outside a synagogue, where he fired shots at the security staff on duty and at the police. A volunteer private security guard was killed at the scene and two officers were hit by shots.

Later the same morning, just before 5 am, the presumed perpetrator was identified elsewhere in Copenhagen. During the subsequent exchange of fire with the police action force, the perpetrator was killed.

The perpetrator was known to the police for a number of criminal activities, including violence and breaches of the Danish Arms Act, and had most recently been released from custody on 30 January 2015. He was also known for gang involvement.

The incidents led to one of the biggest unplanned police operations in Denmark in recent times.

Characteristics

According to Section 114 of the Danish Penal Code, the term 'terrorism' covers a range of serious offences (murder, bombing, arson, kidnapping, hijacking, etc.) committed 'with the intent to seriously intimidate a population or unlawfully to compel Danish or foreign public

authorities or an international organisation to do, or to abstain from doing, any act or to destabilise or destroy the fundamental political, constitutional, economic, or social structures of a country […], provided that the offence may inflict serious harm on a country or an international organisation by virtue of its nature or the context in which it is committed'.

The global threat picture is dynamic and characterised by ever-changing trends and challenges. In recent years, there has been a marked increase in the number of terrorist attacks and attempted attacks on the West, conducted in the cause of militant Islamism. Most of these have been simple attacks by individuals or small groups, causing limited immediate damage. However, several examples in recent years have also shown that there is also a danger of more complex attacks in which many civilians may be killed and injured.

For a number of years, Denmark – in line with a number of other countries – has faced an increasing and serious threat from terrorism. The circumstances that form the threat picture against Denmark are constantly changing, which means that the authorities need to be continuously adjusting their security and preparedness efforts, and their arrangements to combat terrorism.

The Centre for Terror Analysis (CTA), part of the Danish Security and Intelligence Service (DSIS), assesses the terror threat to Denmark and Danish interests abroad. The current assessment of the terror threat to Denmark can be found at pet.dk.

Risk Outline

Occurrence
The terror threat to Denmark is serious. It is a fact that there are people with the intention and the capacity to commit terrorist attacks in Denmark. Nevertheless, the probability of becoming a victim of a terrorist attack in Denmark is limited. The terror threat is considered

overwhelmingly to come from people sympathetic to militant Islamism. They are motivated by a perception that Islam is under attack from the West, by opposition to Denmark's active foreign and security policy, and by the 'cartoons case'. Militant Islamist propaganda is disseminated globally on social media platforms, exhorting supporters to attack targets in the West or Western targets in non-Western countries.

The conflicts in Syria and Iraq have helped create a new generation of militant Islamists, who are now greater in number, and more militant, anti-Western, and brutal toward their perceived enemies. The aforementioned conflicts in Syria and Iraq are significant factors in the current threat picture, along with the group that calls itself Islamic State (IS). The group's propaganda can influence people in Denmark into committing acts of terrorism or travelling to Syria or Iraq to join the group. The group can also direct attacks aimed at Denmark. Militant Islamist propaganda is increasingly urging attacks directed at random, unprotected civilian targets.

It is thought that, over the next few years, the new generation of militant Islamists will present a challenge to the West, including Denmark. This will also apply in a situation where militant Islamist groups such as IS come under growing military pressure in Syria/Iraq. Pressure of this kind may mean that fewer people travel from Denmark to join IS in Syria or Iraq, but it may also mean that more people who have gained capabilities with militant Islamist groups return home to Denmark.

Islamist groups disseminate propaganda aimed at easily influenced people in the West, which also helps to radicalise people and communities in Denmark. Typically, persons with no experience from conflict zones who have fallen under the influence of the propaganda and guidance of militant Islamists, commit simple attacks using readily available means following a brief planning phase. The attacks are often committed alone or in a small group. The attacks can be conducted to greater effect if the people have gained capabilities, e.g. from a criminal environment. The attacks of 14 and 15 February 2015 on the Krudttønden cultural centre and the synagogue in

Challenge Pattern:

Terrorist Acts

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident
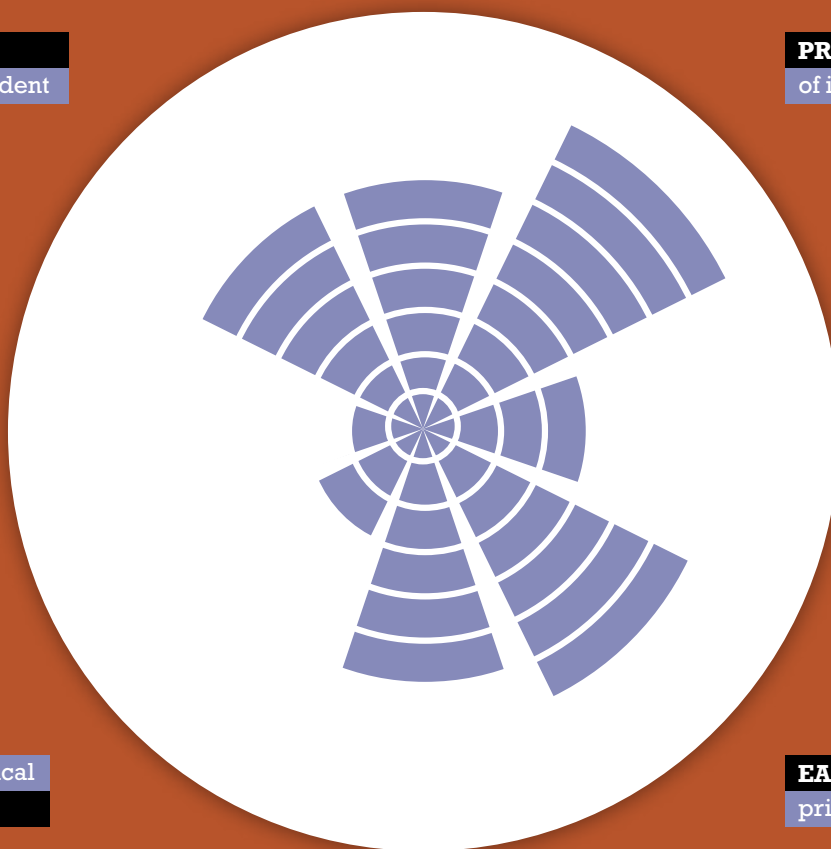
FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Terrorist acts are deliberate actions, and preventing them requires a considerable and continuous effort. The perpetrators may carry out acts without prior planning, or they may plan actions without the knowledge of the authorities, and these may be quite deliberately surprising in their nature and have very serious consequences. Whatever the actual consequences, terrorist acts and attempted acts are usually followed by drastically raising the level of alert, which can be difficult to reduce later.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Copenhagen were examples of this kind of attack. Relatively simple attacks from individuals or small groups continue to be regarded as the most likely form of terrorist attack in Denmark.

Militant Islamic propaganda continues to influence individuals in Denmark into travelling to conflict zones, such as Syria or Iraq. Spending time in a conflict zone can lead to Militant Islamists' radicalisation, brutalisation, and a readiness to use violence. Through battle experience and training, those who have travelled out there can increase their capacity to commit terrorist acts. The risk of attacks increases as a result of the presence in Denmark of people who have returned home from Syria and Iraq after acquiring military skills and battle experience, as well as that of people who have acquired similar capabilities from criminal environments, for example.

The large number of people travelling to conflict zones can increase the possibility of militant Islamists forming networks across national borders. Therefore, attacks may take place in Denmark committed by people travelling here from other European countries. Similarly, militant Islamists from Denmark may be involved in terrorrelated activities in other European countries.

IS has also demonstrated its ability to carry out relatively complex terrorist attacks in the West, hitting multiple targets and killing many civilians. Powerful radicalisation and brutalisation can increase the level of brutality in terrorist attacks, as well as the risk of suicide attacks. The influence of propaganda and from radicalised returnees from a conflict zone may mean more attacks targeting random civilians, including in Denmark.

As well as the threat from militant Islamists, there is also a threat from those in politically extreme environments in Denmark, who are prepared to use violence to further their agenda.
The violence may be directed at political opponents, minority groups, organisations, and companies attributed a symbolic value. This threat is considered to be limited.

The increasing focus on refugees and migrants by persons involved in political extremist environments, or by those with extremist sympathies, may increase the threat to asylum centres, refugees, migrants, and the affected authorities. The mobilisation of right-wing extremists with regard to refugees and migrants may lead to counterreactions from militant Islamists or left-wing extremists.

Consequences

In the first instance, the possible consequences of a serious terrorist act could be human fatalities and injuries. The damage site could also pose a danger to emergency service personnel, as more attacks may have been planned to follow immediately after one another.

Survivors may suffer major psychological consequences, even if they did not sustain any serious physical injuries. This may, for example, be trauma, anxiety, stress, and a feeling of insecurity, which may arise immediately or long after the attack and may be transient, long-lasting or permanent. The relatives and close friends of victims can also experience similar symptoms. Finally, terrorist acts can have a fear-inducing effect on the population as a whole.
Even among populations that have experienced repeated terrorist acts, however, this effect appears to be limited and to fade relatively quickly. Feelings of insecurity are primarily expressed as an increased vigilance, and only to a limited extent do they lead to any negative or inhibiting behavioural changes. Terrorist acts can result in damage to, or loss of, property, especially in the case of bomb attacks. Although the real targets of attacks are usually people, pressure waves, heat build-up, fires, and smoke can cause significant damage in the immediate vicinity of the crime scene. This can lead to major costs for clean-up and restoration, which can also take a long time.

Maintaining a high level of terrorism preparedness involves major financial costs to society. Physical security installations, staffing, and special security procedures all contribute to this. For example, periods during which there is a

Consequence Pattern:

Terrorist Acts

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

particular need for visible guarding and patrolling use up a large number of police man-hours. Such a peak load can lead to economic and administrative consequences that well outlast the duration of an anti-terror operation in itself.

Examples

The only major coordinated bomb attack to have taken place so far in Denmark was conducted on 22 July 1985 in the centre of Copenhagen. First, a bomb was detonated at the office of the American airline Northwest Orient Airlines in Vester Farimagsgade, Copenhagen. Just a few minutes later, a second bomb exploded at the Danish Jewish Congregation's synagogue in Krystalgade. A third bomb, which was discovered in Nyhavn, was presumably intended for the office of the Israeli airline El Al. A number of people were injured in Vester Farimagsgade, with one person dying from his injuries a few days later. Twentyseven people were injured in Krystalgade. A Shia Muslim terrorist organisation took responsibility for the attacks, and in 1989 three Palestinians were sentenced to life imprisonment.

Since 2008, militant Islamists have on several occasions planned and attempted to carry out attacks on people and locations in Denmark. In the autumn of 2009, two people of American-Pakistani background were arrested in Chicago for planning a terrorist attack on the newspaper Jyllands-Posten. The two men had obtained information about possible targets for the attack, and one of them had visited and filmed the offices of Jyllands-Posten in Århus and Copenhagen, as well as performing reconnaissance on alternative targets.

On 10 September 2010, a male traveller of Chechen-Belgian origin inadvertently detonated a bomb in a bathroom at Hotel Jørgensen in Copenhagen, during which he himself was injured. It is thought that he was in the process of preparing a parcel bomb intended for the office of Jyllands-Posten in Viby. In May 2011, he was

sentenced to 12 years' imprisonment for attempting to perform a terrorist act and for breaches of the Danish Arms Act.

On 29 December 2010, three men of Tunisian, Lebanese and Egyptian origin, who had entered Denmark from Sweden, were arrested by the Special Intervention Unit of the Danish Security and Intelligence Service at a flat in Herlev. They were suspected of having imminent plans to force their way into the Jyllands-Posten/Politikens Hus news corporation in Copenhagen and kill as many people there as possible. At the time of their arrest, they were in possession of a machine gun, a pistol, ammunition and 200 plastic strips, which can be used to tie people's hands. The three men, along with an accomplice in Sweden, were all sentenced to 12 years' imprisonment in June 2012.

Other Danish cases of militant Islamist terrorist activity include the terrorism case from Glasvej in Copenhagen, in which two people were sentenced to lengthy terms of imprisonment in 2008, and the cases from Vollsmose and Glostrup, in which several people were similarly sentenced to lengthy terms of imprisonment in 2007 and 2008.

The terrorist attacks in Norway on 22 July 2011 also gave Denmark good reason to strengthen its terrorism preparedness. With the combination of a fertiliser bomb in a parked vehicle in Oslo's government district and a mass shooting at a political summer camp on the island of Utøya, the perpetrator killed eight and 69 people, respectively. The attack was carried out by a lone perpetrator and motivated by a fabricated extremist right-wing ideology. There were no indications warning of such an attack in Norway prior to the incidents.

The militant Islamist propaganda that is currently being disseminated globally – on social media platforms, for example – exhorts individuals to attack targets in those countries that are taking part in the international coalition against IS. The vast majority of the attacks carried out against the countries of the coalition are simple attacks by individuals who have been inspired by IS propaganda. The attacks of 14 and 15 February

2015 on the Krudttønden cultural centre and the synagogue in Copenhagen, as well as a number of the attacks in France, Germany, and Belgium during the summer of 2016, were examples of this kind of attack.

At the same time, IS is attempting to carry out relatively complex and coordinated terrorist attacks in the West, hitting multiple targets and killing many civilians. The terrorist attacks in Paris on 13 November 2015, and those in Brussels on 22 March 2016, demonstrate that IS has such capacity.

During the attack in Paris, a number of coordinated attacks were performed on unprotected civilian targets in the centre of Paris and in the suburb of Saint-Denis. Nine perpetrators attacked five different, unprotected civilian targets using automatic weapons and suicide bombs: restaurant guests, a concert audience, and spectators at a football match. The attackers killed 130 people and left 413 injured.

On 22 March 2016, the airport at Zaventem and the Metro station at Maalbeek in Brussels were subject to terrorist attacks carried out by five perpetrators. The attack was conducted as suicide attacks using homemade bombs manufactured from TATP and hidden in bags and trunks. A total of 32 people were killed and 340 injured. IS assumed responsibility for the attacks in both Paris and Brussels.

Key Actors

- **Danish National Police**
- **Danish Security and Intelligence Service**
- **Centre for Terror Analysis**
- **Danish Defence Intelligence Service**
- **Danish Emergency Management Agency (DEMA)**
- **Defence Command Denmark**

- **Danish Health Authority**
- **Ministry of Foreign Affairs of Denmark**
- **Danish Transport, Construction and Housing Authority**
- **Danish Regions**
- **Municipalities**

What if…

…a coordinated attack were to strike a major Danish city?

First, a number of bombs are detonated close to a major outdoor gathering of people.
Shortly afterwards, automatic weapons are fired in several of the city's restaurants and entertainment venues.
**People flee, and there is traffic chaos on the narrow streets, that act as bottlenecks.**

A shootout with the police develops, and at the same time it becomes apparent that two of the perpetrators have fled with hostages and entrenched themselves in a random store in a nearby suburb.

The police and rescue team in Oslo's government district after a fertiliser bomb exploded in a parked car in 2011. Eight people were killed and numerous buildings were damaged. Image: Scanpix.

13.

Space Weather
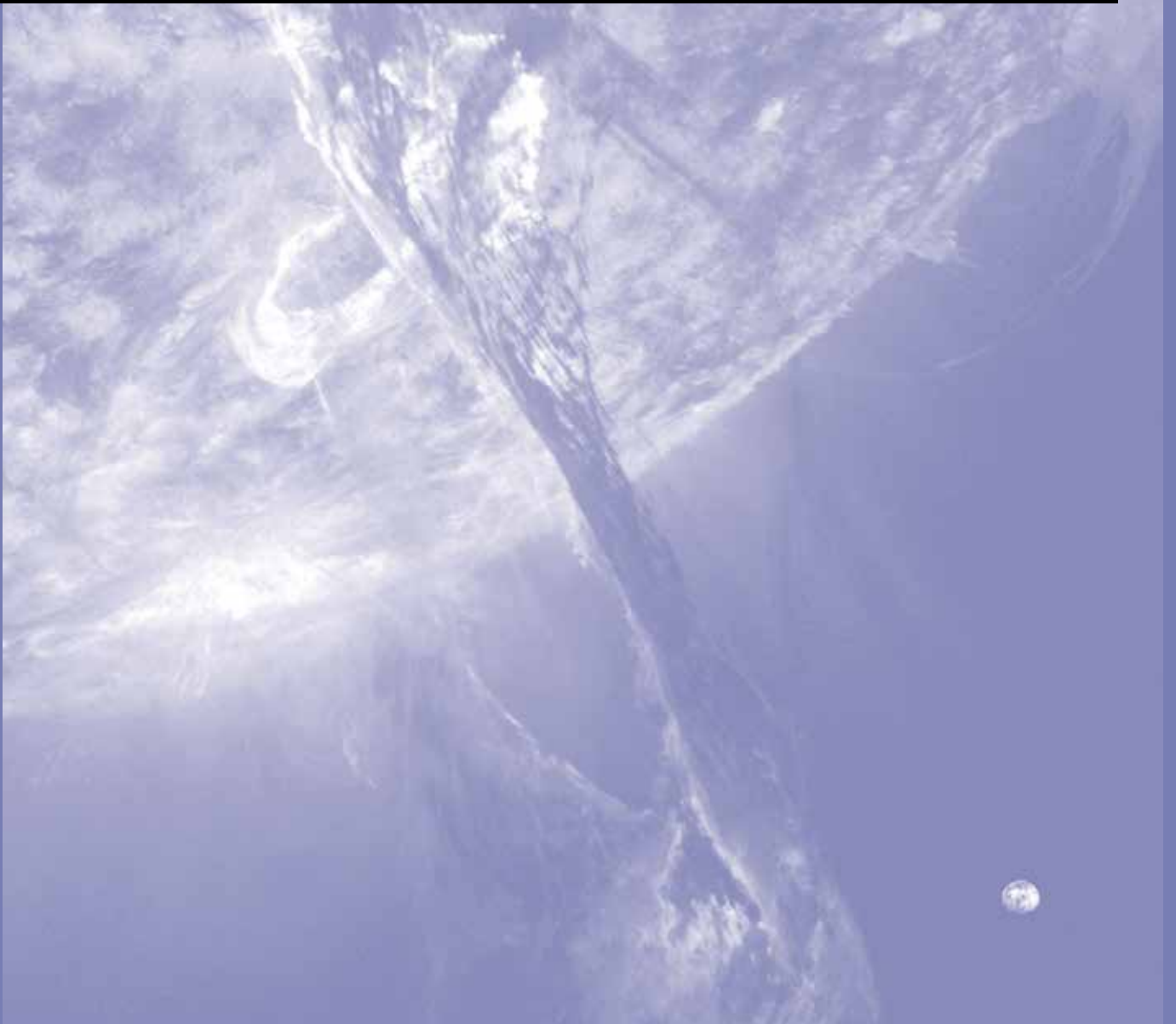
A Coronal Mass Ejection (CME) on 31 August 2012. Here, plasma is thrown out from the surface of the Sun at a speed of more than 1,400 km/s. The Earth is shown at the correct size, but not distance, relative to the Sun.
Image: NASA/Goddard Space Flight Center

Towards the end of October 2003...

the Earth was affected by a number of geomagnetic storms that created problems worldwide.
Communications and navigation systems became unreliable and, particularly near to the polar areas, flights had to be diverted or cancelled, leading to a large number of major delays. The Japanese space agency permanently lost contact with, and control of, the ADEOS-II climate satellite and the DRTS/Kodama communications satellite. Several other satellites were temporarily unresponsive or unreliable.

There was disruption to the power grid in southern Sweden, with several substations suffering overvoltage overloads. For a time, 50,000 people in and around Malmö were without electricity. Similar problems occurred in South Africa.

The 'Halloween Storms', as the phenomena were later named, were part of a number of space weather phenomena that affected the Earth

Characteristics

'Space weather' is a term used to denote various physical conditions that apply in outer space, i.e. beyond the Earth's atmosphere. In our solar system, the determining factor for space weather is the Sun. The Sun is constantly hurling a large quantity of particles into the space around it (protons, electrons, and alpha particles). This stream of particles is called the solar wind.

By the time it reaches Earth, the solar wind is normally travelling at speeds of around 400 km/s, and it makes up most of the cosmic radiation that affects Earth. At high doses, radiation is harmful to human health. However, the Earth's magnetic field, and the outermost part of our atmosphere, protect life on Earth from the majority of the harmful effects of the solar wind. When fluctuations occur in the intensity of the solar wind, the magnetic field partially mitigates the effects, so the radiation level on Earth remains fairly constant. At the

same time, however, the pressure from the solar wind 'pushes' and 'stretches' the Earth's magnetic field, so that it is not evenly distributed around the Earth.

Conditions on the Sun's surface are very changeable, and there are large variations in both the Sun's (numerous) magnetic poles and local temperatures. We can observe this from Earth as well as from satellites dedicated to solar research, for example in the form of sunspots (temporary darker areas on the Sun) and solar eruptions. A solar eruption is a violent explosion in the Sun's atmosphere, during which a particularly large amount of energy is released and hurled out from the Sun together with the solar wind.

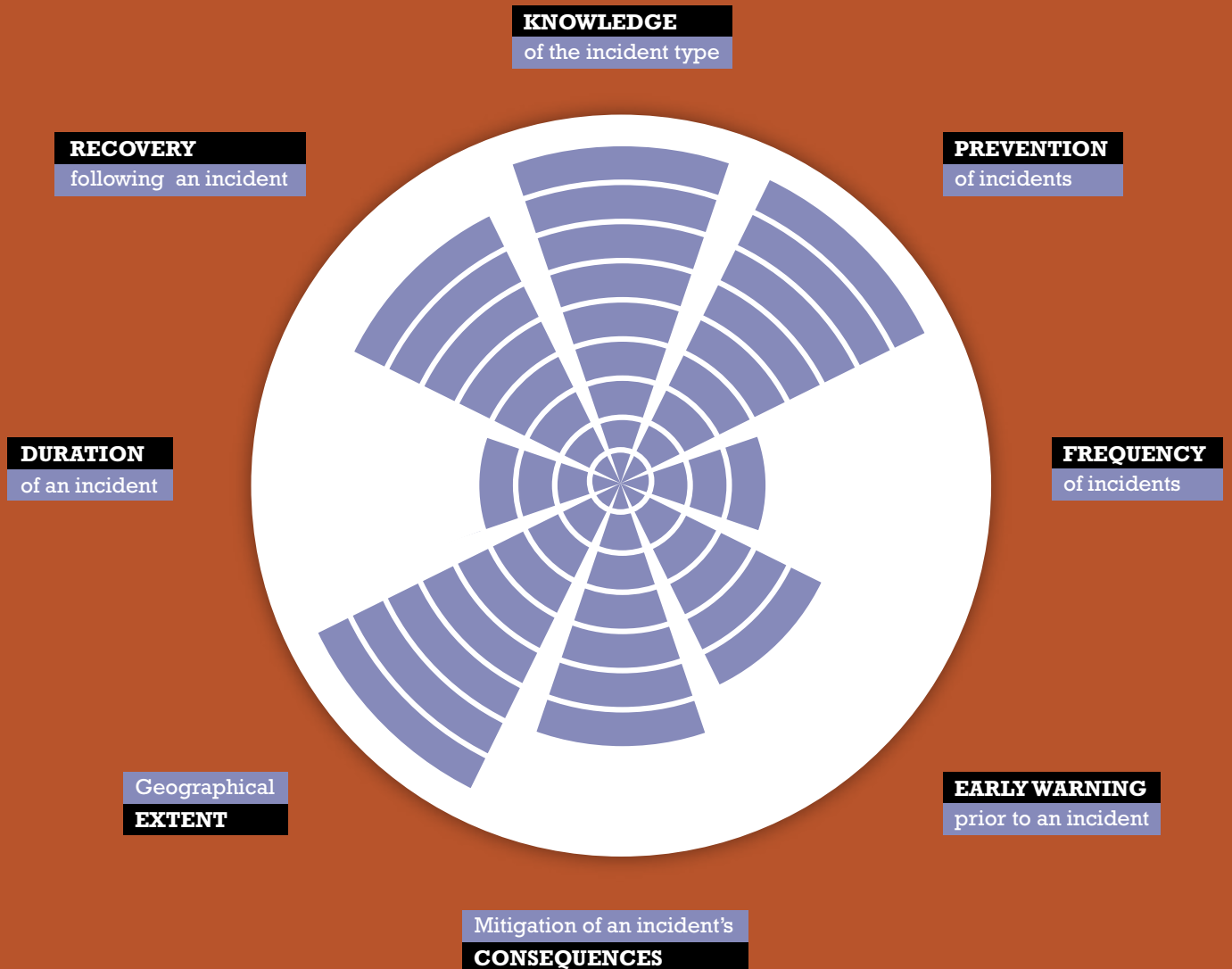'Solar eruption' is a broad term for three types of phenomena:

- 'Flares', which consist of electromagnetic radiation (X-rays and ultraviolet radiation). As this radiation travels at the speed of light, flares are the first visible sign of a solar eruption.

- 'Solar Energetic Particles' (SEPs), which are charged particles moving close to the speed of light, and which therefore reach the Earth a fairly short time after a flare can be observed.

- 'Coronal Mass Ejections' (CMEs) consist of plasma moving at speeds of between 400 and 2,500 km/s – though in most cases, they are moving at speeds at the slower end of the range. The transit time from the Sun to the Earth is typically around a few days, though for the fastest CMEs this can be as short as 17 hours. CMEs, in particular, can disturb the Earth's magnetic field and cause geomagnetic storms.

The solar wind, which otherwise affects the Earth at a fairly constant strength, can become temporarily – but dramatically – amplified by flares, SEPs, and CMEs in the immediate aftermath of a solar eruption.

There are various conditions that determine how we experience a solar eruption on Earth. A solar eruption of a given size will not always result in the same degree of consequences on Earth. This is partly due to the fact that the Earth's magnetic field will interact with the amplified solar wind and mitigate its effects to various degrees. The magnetic field bends inwards around the Earth's North and South magnetic poles, and therefore very high northern and southern latitudes are particularly exposed to charged particles. A visible (and completely harmless) example of this is the Northern Lights.

As the magnetic field is uneven and dynamic, the negative consequences of solar eruptions – which can include interruptions to power supplies, disruption to the communications infrastructure, and the breakdown of other types of electrical equipment and systems – are usually experienced differently from one locality to another, even though flares, SEPs, and CMEs impact the entire Earth.

Challenge Pattern:
Space Weather

KNOWLEDGE
of the incident type

RECOVERY
following an incident

PREVENTION
of incidents

DURATION
of an incident

FREQUENCY
of incidents

Geographical
EXTENT

EARLY WARNING
prior to an incident

Mitigation of an incident's
CONSEQUENCES

Even though we are aware of the phenomena when they occur on the Sun, there are many unknown factors when it comes to the consequences on Earth and the specific effects on our infrastructure. The triggering phenomena are unavoidable, and preventing the consequences is at best expensive, difficult, and protracted. The consequences can potentially affect the entire globe at the same time, and it is difficult to predict what cascading effects an incident may result in.

The circle chart runs from the centre (low) to the periphery (high). The extent of the purple shading shows the degree to which the parameter in question typically constitutes a challenge when society is faced with an incident of this type. The challenge pattern expresses an assessment and draws a characteristic 'fingerprint' of the incident (refer to page 9 and 10 for further explanation).

Risk Outline

Occurrence

The frequency of solar eruptions (and, therefore, of flares, SEPs, and CMEs) is closely associated with the number of sunspots on the Sun's surface. From records going back to the mid-18th century, we know that sunspot activity follows a cycle of higher and lower intensity. A solar cycle typically spans 11 years from one high or low intensity period to another. In 2016–19, we are at a low point in this cycle.

Statistically, during a low intensity period a CME occurs every five days. During a high intensity period, there may be three per day. However, the consequences of solar eruptions are not always noticed on Earth, even though they are observed on the Sun. This is due to the fact that the Earth's position in its orbit around the Sun does not always coincide with the direction in which the particles and plasma are being ejected. For example, in 2012 the Earth was close to being struck by the effects of a very powerful solar eruption that nonetheless passed by. Had the eruption occurred just a week earlier, it would have affected the Earth.

Massive individual solar eruptions can also occur at times of low overall sunspot activity. In fact, particularly serious solar eruptions appear to occur more often during the declining period of a cycle. At the same time, over the past 60 years we have seen a higher level of sunspot activity than we generally saw during earlier periods. Solar eruptions occur with relatively high frequency and will undoubtedly occur in future. When an eruption will next have detrimental consequences on Earth will, however, depend on the nature, strength, and direction of the eruption, as well as the Earth's position in its orbit at the particular time of the eruption. Thus, a number of unfortunate circumstances need to coincide before space weather will have any serious negative consequences on Earth.

The Sun is 4½ billion years old. Man has lived on Earth for only a tiny fraction of the present lifespan of both the Sun and the Earth. Our knowledge about solar eruptions, which is based on observations over just a few centuries, should be seen in this light. One thing that we cannot determine, for example, is the maximum strength of the space weather that the Sun is able to generate. Flares have been measured from stars in other solar systems where energy levels are around 100,000 times greater than those measured from the Sun. However, stars have different properties and go through different stages of development, so it is uncertain what this means in terms of our solar system.

As a geographically northern country, it is immediately probable that we will experience the effects of space weather in the future in Denmark. To an extent, it is possible to give some warning before the effects of harmful space weather are felt on Earth. This applies mainly to CMEs, as these can take days to reach us. However, if we are to make use of any such a warning, we will need to have prepared arrangements to mitigate the consequences of space weather. For many systems, there is a lack of knowledge today about how they may be affected and what we can do to protect them.

Consequences

Over the past 100 years, we have become ever more dependent on electricity, computers, and other technology – for example, for navigation, information, and communications. Space weather can affect this technology, on which many services in society depend. Our vulnerability to space weather therefore depends on the extent to which we are dependent on individual systems. It is difficult to determine the precise impact of a powerful solar eruption on a given system, as many previous known incidents occurred before these newer technologies existed.

Consequence Pattern:

Space Weather

Hazard potential:

Life

Health

Environment

Economy

Property

Vital societal functions

The figure shows how serious the consequences may be for this incident type, across six different parameters (refer to page 11 for further explanation).

Densely compacted computer chips and advanced electrical devices may possibly prove to be more vulnerable than earlier, more simply built systems. At any rate, electricity, computers, IT, and satellite-borne technology are ubiquitous in our day-to-day lives. Any vulnerabilities in respect of space weather thus have the potential for farreaching consequences.

The phenomenon of 'Geomagnetically Induced Currents' (GICs), in particular, causes problems. When charged particles from the amplified solar wind interact with the Earth's magnetic field, this may generate an electric current by induction in suitably conductive materials. The most obvious example is that of the high voltage transmission lines of the power grid, where GICs can cause overvoltages of up to 20 volts per kilometre of cable. Countries with highly expansive power grids, where there are long distances between individual consumers and substations, are particularly vulnerable in this regard. These conditions do not, at first glance, apply to the Danish power grid. However, Denmark is connected to the Norwegian, German, and Swedish grids, and if overvoltages on these grids cause major electrical problems then – given specific circumstances – these problems could spread to Denmark.

It is possible that GICs may put substations out of operation, resulting in prolonged power cuts. Power cuts lasting more than a few hours can have significant cascading effects in many settings within society.

Radio communication and radar monitoring systems are also vulnerable to space weather. Geomagnetic storms can disrupt signals, and receiver units can be put out of operation entirely. Both of these may render it unsafe for aircraft to land or take off from certain airports for a while. Alternatively, northern-bound flights in particular may be cancelled or diverted.

Satellites, which often orbit in the outermost part of the Earth's protective atmosphere, or entirely outside it, are particularly exposed to space weather. Prior to launch, they are fitted with

special material to shield against particles and radiation from the solar wind, and thus they can to some extent withstand the effects of a solar eruption. However, there are limits to how robust this shielding can be made before the satellites become too heavy to launch. Satellites are therefore vulnerable to powerful solar eruptions. Not only that, but the satellites' solar panels and electronics age very quickly under the exceptional strain to which they are subjected. More serious still, however, is the fact that solar eruptions can put satellites completely out of operation – temporarily or permanently.

There are around 1,300 operational satellites in orbit around the Earth. These serve many different purposes, e.g. observing weather systems on Earth, communications, broadcasting, navigation, and providing precise indications of the time. Our space-based infrastructure has become an infrastructure on the same level as, for example, roads, communications, and the energy network. Satellite-based navigation (GNSS) has by now become a widespread technology in many people's day-to-day lives, as well as a critical element in many industries, such as commercial shipping. High-precision time indication is vitally important in many contexts, for example for the trade in securities and other financial transactions. As more and more day-to-day processes become dependent on a satellite-based infrastructure, it becomes increasingly difficult to maintain an overall image of the precise consequences associated with the loss of a given satellite or satellite system. Many satellite systems consist of several satellites whose functional areas overlap to an extent, while others fulfil a unique task. A powerful solar eruption could have serious consequences for many satellites simultaneously, and/or could affect satellites that perform particularly important functions.

All satellites have a limited lifespan, and there are long-term plans in place for their replacement. However, it typically takes several years to prepare and launch a satellite into orbit. Replacing one or more lost satellites would therefore be a costly and time-consuming process.

Examples

From 28 August to 4 September 1859, several unusually large solar flares were observed. Then, 17½ hours later, the associated CME struck the Earth, causing powerful GICs in the telegraph network. Some telegraph operators received electric shocks, and in some places papers burst into flames in telegraph station buildings, as a result of the overvoltage generated in the long cables. At the same time, the Northern Lights were observed in countries as far south as Senegal, Mexico, Cuba, and Colombia. This incident is known as the Carrington Event, named after the astronomer Richard Christopher Carrington, who studied solar phenomena.

The event is often referred to as the most powerful geomagnetic storm ever known on Earth. Despite its intensity, the consequences were limited as, at the time, there was little in the way of electrically conductive infrastructure, limited dependence on electricity, and no space-based infrastructure. It is uncertain what the consequences of the same event would be today.

In March 1989, a CME and subsequent GICs caused a breakdown of the energy supply in Quebec, Canada. The strength of the CME was much less than that of the Carrington Event, yet it left 6 million people without electricity for nine hours and led to major economic losses as a result. At the same time, airline pilots reported noise on the radio lines, while numerous ships lost radio contact with land. Communication with several satellites was also disrupted for many hours, and a large quantity of weather data was lost. In space, the gauges on the 'Discovery' space shuttle showed incorrect readings.

Later, in August of the same year, a separate GIC event caused breakdowns of Canadian PCs. As one effect of this the stock exchange in Toronto was forced to close for all trading in securities for three hours due to computer failure.

On 4 November 2015, a solar eruption disrupted radar systems in Sweden to such an extent that it was no longer safe to allow planes to take off and land at Swedish airports. The closure of Swedish airspace created delays and cancellations of scheduled flights – including some outside Sweden – but there were no accidents as a result of the failure. The radar systems in Danish airports operate on a different frequency band to the ones used in Sweden. This was probably the reason why similar disruption was not experienced in Denmark on that occasion.

Key Actors

- DTU Space
- Danish Meteorological Institute
- Danish Agency for Science and Higher Education
- Danish Energy Agency
- Energy supply companies
- European Space Agency (ESA)
- Naviair
- Danish National Police

What if…

…a powerful flare and accompanying discharge of charged particles (SEPs) were to put a number of satellites out of operation? Determination of positions using satellite navigation is imprecise, with periodic outages. TV stations are unable to transmit due to outages of communications satellites.

A few hours later, a CME hits the Earth. GICs cause power cuts in several neighbouring countries. In Denmark, the mobile phone network is affected, along with the emergency management authorities' special communications network (SINE), with periodic disruption to service in parts of the country.

Communication lines are still available, but the lacking newsfeed in the TV media puts pressure on the bandwidth of the Internet, making it difficult to gain an overview of the situation and the reasons behind it…
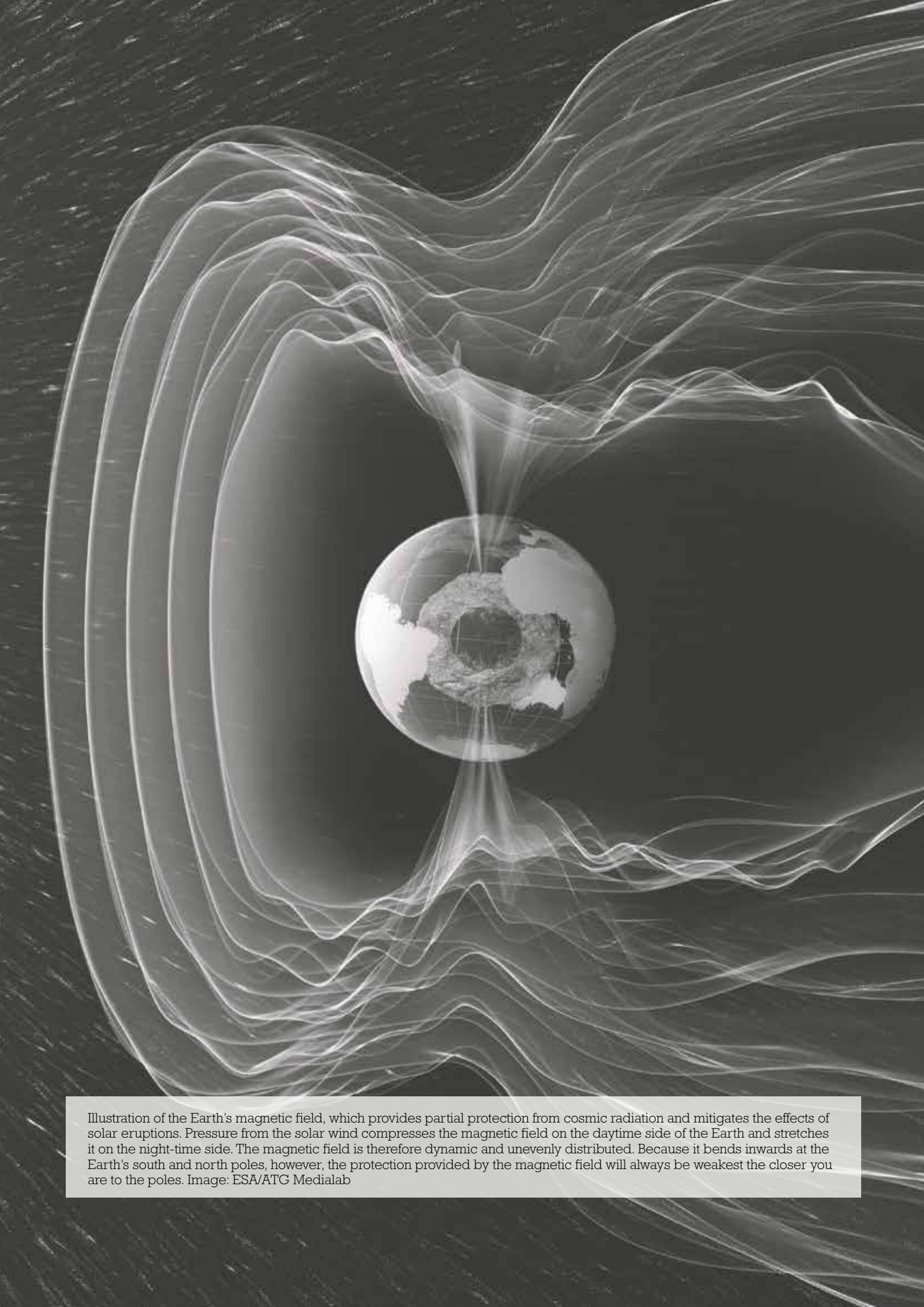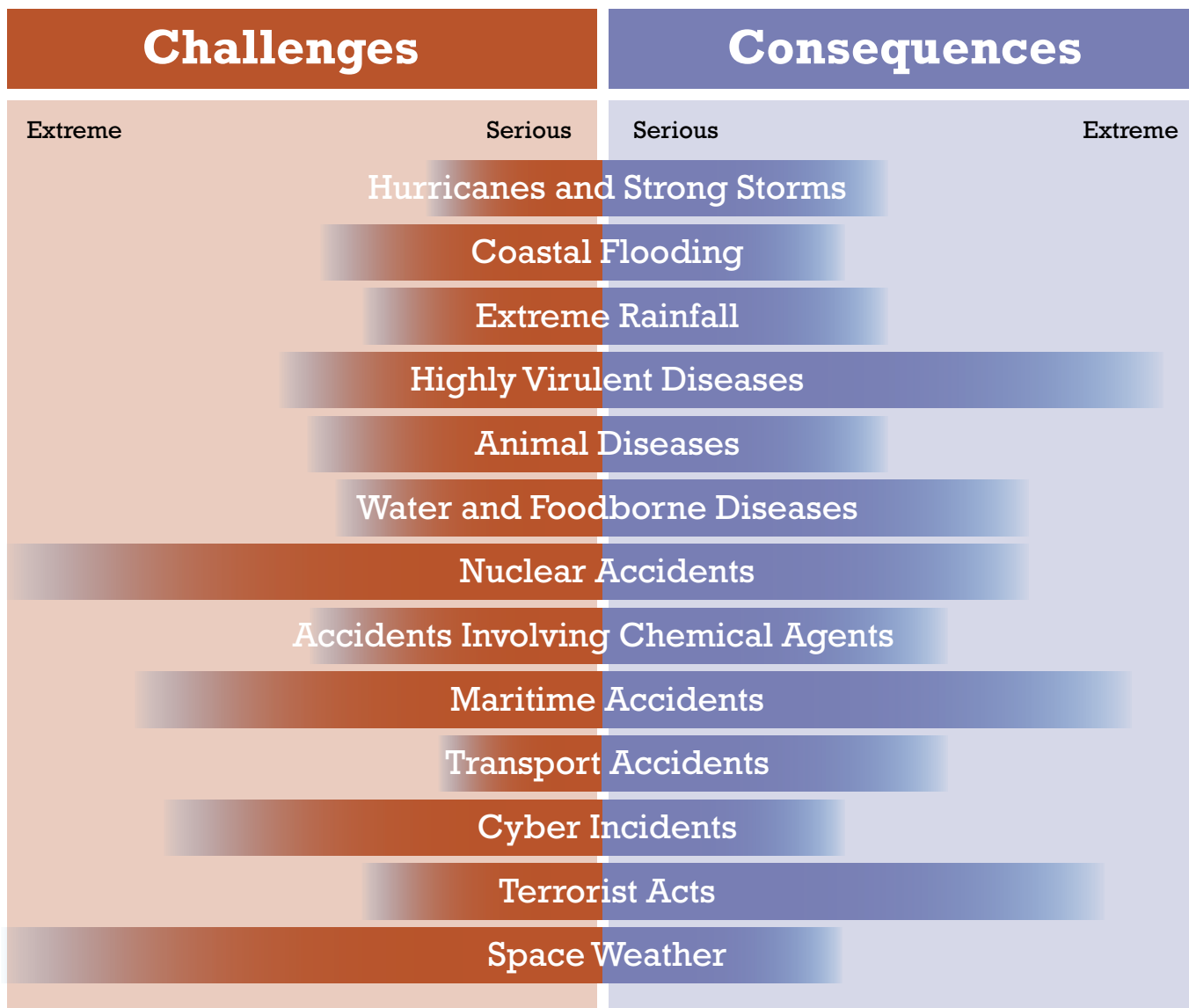
Illustration of the Earth's magnetic field, which provides partial protection from cosmic radiation and mitigates the effects of solar eruptions. Pressure from the solar wind compresses the magnetic field on the daytime side of the Earth and stretches it on the night-time side. The magnetic field is therefore dynamic and unevenly distributed. Because it bends inwards at the Earth's south and north poles, however, the protection provided by the magnetic field will always be weakest the closer you are to the poles. Image: ESA/ATG Medialab

Relative comparison

of the incident types

Challenges	Consequences
Extreme · · · · · · · · · · · Serious	Serious · · · · · · · · · · · Extreme

Hurricanes and Strong Storms

Coastal Flooding

Extreme Rainfall

Highly Virulent Diseases

Animal Diseases

Water and Foodborne Diseases

Nuclear Accidents

Accidents Involving Chemical Agents

Maritime Accidents

Transport Accidents

Cyber Incidents

Terrorist Acts

Space Weather

The extent to the left (orange) shows the seriousness of the overall challenge to society associated with the management of the incident types. The extent to the right (purple) shows the seriousness of the overall consequences that the incident type may have. The extents indicate an order of magnitude and cannot be interpreted as absolute values.

PART TWO

TRENDS

I.

Security Policy
Tensions

Troops in unmarked uniforms at a base in Prevalne, Ukraine. The picture was taken in March 2014, shortly before Russia's illegal annexation of the Crimean peninsula. Image: Anton Holoborodko

Description

The dissolution of the Soviet Union in 1991 in practice meant that Russia went from being one of two global superpowers to being a smaller power with a weakened economy. In subsequent years, recurrent financial problems, China's growth as an economic power factor, etc., have further contributed to weakening Russia's relative position on the international stage.

The expansion of both the EU and NATO, by admitting more member states in Eastern Europe and the Balkan region, has been perceived by Moscow as offensive conduct on the part of the West and as a de facto continuation of the Cold War's policy of containment. The ability to continue pursuing its interests in the former Soviet republics appears to be a vital factor in both Russian politics and Russian military strategy. In addition to this, for many years now an internal policy agenda has fed the Russian desire to regain its position as a major global power.

Relations between Russia and the West in recent decades have been characterised by oscillations between periods of cooperation in areas of common interest (such as international trade and combating terrorism) and periods of tensions in security policy.

Relations have been particularly strained since the start of the Ukraine crisis in 2013. The tensions arising from the Ukraine crisis appear to be more serious, and potentially more long-lasting, than previous crises between Russia and the West. Russia's actions in Ukraine, including the illegal annexation of the Crimean peninsula, constitute clear violations of fundamental principles under international law of national sovereignty, territorial integrity, and self-determination. This has helped to create an image of Russia in the West as a country that does not comply with the principles of international law. Conversely, Russia presumably regards the Ukraine crisis as a necessary brake on western influence in its neighbouring area.

In reaction to Russia's annexation of Crimea and its destabilisation of eastern Ukraine, the EU and a number of other western countries have introduced targeted sanctions against the Russian regime. These involve limiting access to the financial markets, weapon technology, and technology for extracting deep-seated energy resources and those in Arctic areas. Russia it turn then introduced a wide-ranging ban on the import of western agricultural and food products.

To an extent, the political and diplomatic dialogue has also been put on hold, including the biannual EU-Russia summit meetings. However, the meetings of the NATO-Russia Council did resume from April 2016 after a lengthy suspension.

Possible developments

It is considered unlikely that Russia will seek a direct and conventional military confrontation with NATO. On the other hand, attempts will be made with the means available to expose disagreements and weaken the cohesion of the western alliance. Russia appears to be focused on using surprise and unpredictability as strategic elements, which can lead to initiatives that, at first sight, appear contrary to Russia's self-interest. It is therefore difficult to predict Russia's next move.

As far as Denmark is concerned, the situation primarily means an increased risk of escalation in the Baltic Sea and the Baltic states. However, the possibility of Russian initiatives within the borders of the Danish Realm – including the Arctic and North Atlantic – cannot be excluded.

In a European context, we have seen on previous occasions how Russian state-owned energy supply companies have suddenly raised the price of gas several-fold, or threatened to cut off the supply entirely. In 2014, the EU imported 53 per cent of its energy – mainly oil and natural gas – from the Russian market. In the event of an energy shortage, the EU would share the burden among the member states. Although Denmark is a net energy exporter and is less dependent on gas, for example, than are many other countries, any serious instability on the energy markets could still have consequences at home.

As far as internal politics is concerned, the political power in Russia is thought to be tightly

consolidated around President Putin and a narrow political inner circle. At the same time, the political opposition is weak, and conditions for dissidents and press freedom are generally difficult. This is seen, among other things, in a number of killings of journalists critical to the regime, as well as active bureaucratic harassment of certain media platforms and civil society organisations. There do not, therefore, appear to be any prospects in the near future of any profound changes to the strategic objectives and political course currently being pursued by Russia.

It is difficult to imagine relations between Russia and the West improving significantly in the short term. The level of tension will possibly change slightly, but in the coming years tense relations will probably be part of the normal picture.

Significance to emergency management

Tensions over security policy can have negative consequences at many levels. Restrictions in trade damage all parties financially, but tensions can also help to create or exacerbate risks to society in a number of ways. Mutual distrust, and the absence of any constructive dialogue, may mean that Russia and the West will be on their guard against each other. This in itself increases the basis for misunderstandings, which could lead to unintentional escalation or accidents. The limited dialogue has made it more difficult to achieve any transparency with regard not only to military exercises and movements of troops and materiel, but also with regard to military operations such as those in Syria. High risk activity on the part of Russia includes military exercises conducted without prior warning, military flights with transponders switched off, and violations of the sovereignty of western countries' airspace and territorial waters.

High risk behaviour can also increase the risk of civil transport accidents, as planes are more difficult to identify when their transponders are switched off. For example, a Russian surveillance plane (with its transponder off) flew on a collision course with a scheduled SAS flight over the Baltic Sea in March 2014.

The tensions can likewise increase the risk of maritime accidents. This applies especially in the Baltic Sea, but also in Danish inland waters and in the seas around Greenland and the Faroe Islands. Submarines or ships may collide or run aground as a result of performing unnecessarily risky activities. Russia may opt to use submarines to probe or highlight holes in Denmark's sovereignty enforcement in Danish waters or off Greenland and the Faroe Islands, increasing the risk of a submarine accident in Danish waters.

Moreover, the tensions can increase the risk of a cyber attack aimed at Denmark, whether in the form of a major cyber attack on the Danish infrastructure or espionage against Danish companies and authorities. State-run or state-supported groups are thought to have been behind a large-scale cyber attack on Estonia in 2007, as well as an attack on the electricity supply in Ukraine in 2015. It is not unlikely that Russia may wish to initiate similar attacks as part of a deliberate programme of harassment directed at one or more NATO countries. The tensions in security policies also have more long-term and structural consequences for society's state of preparedness. In recent years, NATO has again directed its attention toward the alliance's collective defences. At the same time, an objective has been defined whereby member countries should increase their defence capabilities from now until 2024.

As part of this realignment, NATO has increased its focus on civilian emergency management planning and civil-military co-operation. For example, this means that minimum requirements have been set as to how robust individual member countries must be in receiving refugee masses, and in securing their transport infrastructure, energy, and water supplies, etc. The alliance's crisis management processes and systems are also being revised with a view to there being solid interaction between civilian and military crisis management.

This chapter has been prepared in cooperation with the Centre for War Studies
at the University of Southern Denmark

Antibiotic Resistance
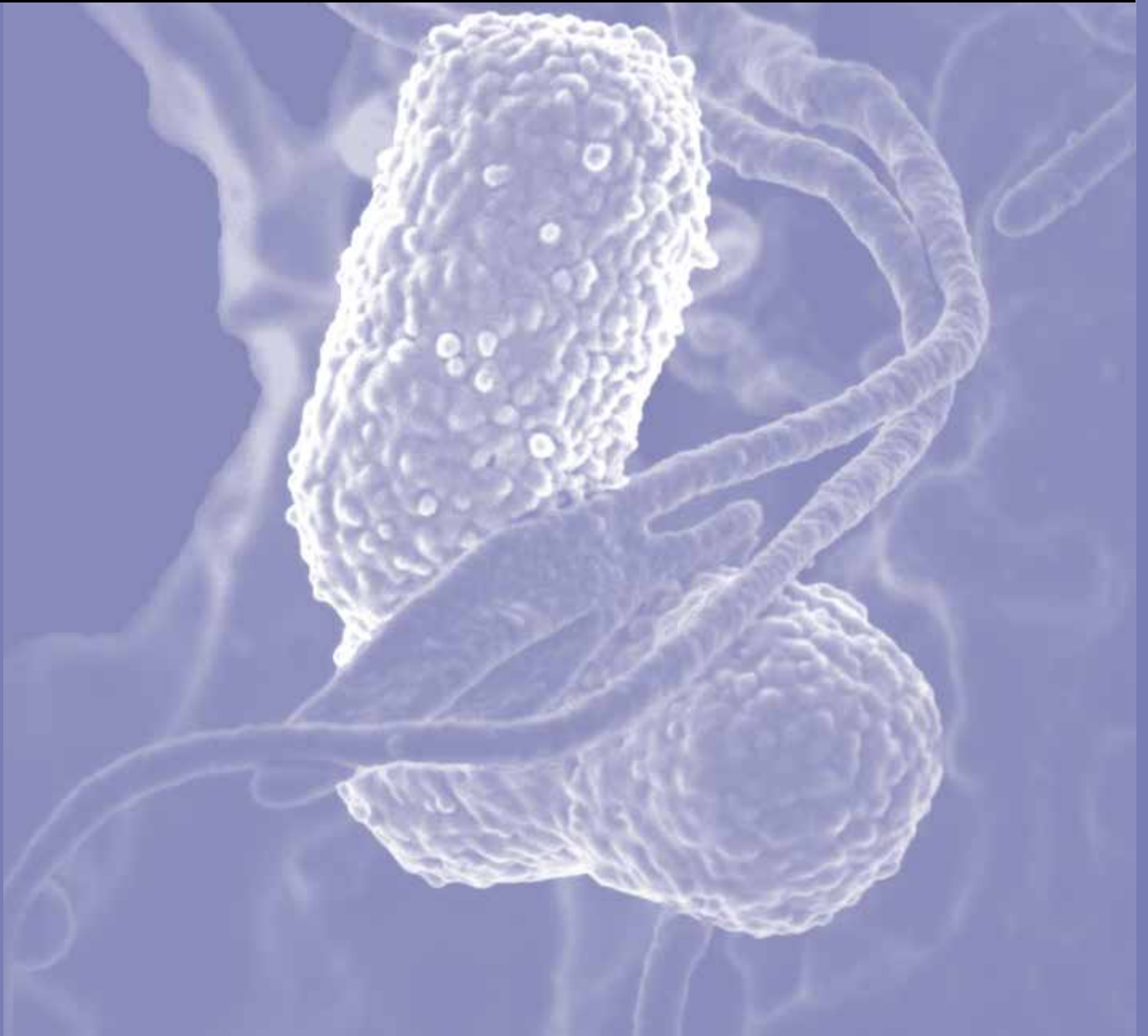
Klebsiella pneumoniae is a bacterium that can cause serious and, in some cases, life-threatening infections, particularly in people with impaired immunity. The bacterium is able to produce an enzyme called 'ESBL', which makes it resistant to a number of types of antibiotic. Both worldwide and in Denmark, during the past ten years we have seen an increasing prevalence of ESBL-producing bacteria, and the WHO currently considers this type of resistance to be one of the three biggest threats to world health. Image: David Dorward/NIAID

Description

'Antibiotics' is a generic term used for a range of substances (including penicillin) that are used to fight infections caused by bacteria. Antibiotics have existed as medicines since the early 20th century, which saw – among other things – Alexander Fleming's discovery of penicillin in 1928. The therapeutic breakthrough occurred in the 1940s with the treatment of soldiers during the Second World War. With the advent of penicillin, it became possible to treat a range of previously serious infections – scarlet fever, wound infections, meningitis, etc. Within only a few years of the introduction of penicillin, however, the first penicillin-resistant bacteria emerged, making antibiotic treatment more difficult.

When a bacterium becomes resistant, it means that antibiotics no longer work on an infection caused by this bacterium. Some bacteria can even be 'multi-resistant', i.e. they are resistant to several types of antibiotic.

Resistance is usually triggered when bacteria mutate, i.e. when genetic changes arise in the bacterium that make it resistant to antibiotics. Some types of resistance can spread only within the same species of bacterium, while other types can spread across different species of bacteria and thus pose an even greater threat to public health.

The development of resistance is usually linked to the presence of antibiotics, where the bacterium has the opportunity over time to adapt to the antibiotic-containing environment.
Treatment with antibiotics leads to what is termed 'selective pressure' in the human body. Here, sensitive bacteria die, while bacteria with various resistance mechanisms survive and have the opportunity to multiply in greater numbers. The more we use antibiotics, the more this selective pressure accelerates.

Worldwide, ever more people now have access to antibiotic treatment, while at the same time modern modes of treatment and surgery often involve the preventive use of antibiotics. Finally, antibiotics are used intensively in livestock production throughout the world, applying additional pressure in terms of resistance development, including the transfer of forms of resistance be-tween animals and people.

Around the 1950s, major problems were experienced in Denmark with resistant strains of staphylococci in hospitals, which particularly affected those patients who were already weakened. In the period following this, there was intensive investment in a range of new antibiotics, including broader-spectrum types that can be used against even the most difficult types of infection. However, time has shown that the pattern is repeating itself, with the new and increased use of antibiotics leading to new and increased forms of resistance.

Slowly, recognition emerged of the need for more and different measures to preserve the effectiveness of antibiotics. In the 1990s, Denmark was one of the first countries in the world to implement a programme of formalised, multi-disciplinary cooperation to combat antibiotic resistance. This included the introduction of a ban on the use of antibiotic growth promoters in livestock. Cooperation between the health, food, and veterinary authorities, along with continuous political initiatives, has meant that – compared with other countries – antibiotic use has become low in Denmark, with a low level of resistance development, and that serious failures in treatment as a result of resistant bacteria are still seen relatively rarely in Denmark.

Over the past ten years, globalisation, including the increased trade in food products and travel activity, has led to an increasing incidence of rare forms of resistance. The national selective pressure has also increased, among other things in the form of an increase in the use of antibiotics in certain areas of application. Resistance development has, at the same time, overtaken the development of new antibiotics, and on a global scale there are now bacteria that cause infections in humans for which no antibiotic is available that can be used to treat the patients. This means an increasing number of patients whose treatment is prolonged or made more complicated by the lack

of effective antibiotic therapeutic agents. This loss of treatment options also leads to some fatalities. The European Centre for Disease Prevention and Control (EDCD) thus estimates that 25,000 people a year in the EU alone die as a result of antibiotic resistance.

Possible developments

Although antibiotic resistance had been on the Danish and Nordic political agenda since the end of the 1990s, it was not until during the 2000s that the concerns led most EU countries to set up monitoring systems, policies, and guidelines on antibiotic use and resistance.

Currently, the EU cooperative venture (under the auspices of the ECDC) includes epidemiological surveillance, monitoring, reporting, and the combating of cross-border health threats, including resistance development. As new and more serious forms of resistance continue to be documented, the political recognition of the problem and willingness to act increase.

Developments on a global level, however, lag far behind. A British report from 2016 estimated that, in the year 2050, ten million people will die each year worldwide as a result of untreatable bacterial infections. In the USA, it is still permitted to use antibiotic growth promoters (prescribed by veterinary surgeons) in livestock, while in India and China there are reports of serious forms of resistance and failing treatments. At the same time, the latter two countries appear to have neither the same willingness nor the ability to introduce restrictions in the area that may help to promote a more sensible use of antibiotics with a view to slowing down the development of resistance.

Globally, however, we have seen an increasing awareness of the problems of resistance – urged on by, among others, the World Health Organisation, which has adopted a global action plan in the field and designated antibiotic resistance as one of the biggest threats to world health.

Even though work is being conducted at national, EU, and global level to combat antibiotic

resistance, this is a trend that is difficult to reverse, due in part to the complex and cross-border nature of the problem.

It is thus not inconceivable that Denmark may import forms of resistance that cannot be defeated by antibiotics, and that such bacteria may be able to spread in the form of a number of outbreaks. For example, in North Zealand in 2008 there was the first major outbreak of multi-resistant Klebsiella pneumoniae. Here, the patients developed urinary tract and bloodstream infections that could only be treated using alternative antibiotics, while at the same time several patients became carriers of the resistant bacterium. Similarly, in the past ten years we have for the first time seen infection with so-called carbapenem-resistant bacteria (CPE) across hospitals and regions.

It is particularly worrying that there do not appear to be any promising new antibiotics in the pipeline from the pharmaceutical industry. At a political level, there are discussions on how to facilitate and increase the research being conducted in this area, how to strengthen the collaboration with the pharmaceutical industry, and how to raise the financial incentives to develop new antibiotics. Typically, however, research into and development of new drugs is a long-term prospect, and no breakthroughs are expected within the next few years.

Even though these days we are mobilising a global and national effort to combat antibiotic resistance, the world – including Denmark – is facing a threat, the scope of which we are not yet aware of as we look forward 20–30 years in time.

Significance to emergency management

The consequences of this development of resistance in terms of society's preparedness, and its importance with regard to the risks posed to society, principally affect the health care sector. Some of the consequences of antibiotic resistance are known and are already being experienced today. If this development continues, and the immediate impression is that it will, then the

gravity of the consequences may become far greater.

For the first time in history, the health care sector of the future could be less able to treat certain patient groups than it was the case in previous generations. Widespread resistance to antibiotics may lead to a loss of treatment options in several areas. Modern forms of treatment, such as for cancer, as well as most surgical procedures, require preventive or post-treatment antibiotic treatment. If antibiotics have no effect, many treatments currently considered as routine may become difficult or totally impossible to perform. The treatment of extremely premature babies is another area in which the treatment options, which are currently good, will become significantly compromised without the use of effective antibiotics. For patients and their relatives, the loss of treatment will lead to a more protracted and complicated course of disease, as well as unnecessary deaths. Longer periods of admission and more demanding procedures will lead to rising costs and lower efficiency in the health care sector.

This applies not only just to hospitals but also to the institutions where nursing care and rehabilitation take place. Apart from the direct costs, prolonged courses of disease can also have knock-on effects on society's productivity in general.

Despite restrictions in the use of antibiotics in pig production, the antibiotic-resistant bacterium, Methicillin-resistant Staphylococcus aureus 398 (also called livestock-associated MRSA or LA-MRSA), occurs frequently in Danish pig herds. MRSA is not a disease in itself; it is a bacterium that can cause various types of infection. The bacterium may be transmitted to people if there is daily and prolonged contact with pig herds carrying MRSA 398. On the other hand, MRSA 398 is rarely transmitted from person to person.

It must be considered that the modern health service, and the general improvements in hygiene in society, will be able to ensure that antibiotic resistance does not spread epidemically. The exception here, however, is LA-MRSA, which has spread dramatically in some parts of the community. It does not, though, appear to spread among vulnerable patients in hospital, due in part to the national guidelines on isolation and hygiene. With a growing number of 'imported cases' – resistance acquired abroad – it will be necessary to detect resistance at an early stage in order to avoid the spread of infection and to ensure that the challenges to treatment are reduced to as few people as possible.

III.

Irregular Migration

Irregular migrants on their way to Europe are rescued in the southern Mediterranean. After arriving in Southern Europe, many irregular migrants attempt to continue to other EU countries. Image: Irish Defence Forces

Description

Migration has always been a central factor in the development of mankind and the world. Large population groups have been moving within and across the continents for thousands of years. The Nordic Vikings migrated to Normandy, England, North America, and Greenland, among other places. The Dutch settlement of Store Magleby in Amager is an example of the influence exerted by Dutch migrants to Denmark, while Danes, Swedes, and the Irish emigrated to the USA in large numbers between 1870 and 1914, making their mark on the places where they settled. In other words, migration is a well-known phenomenon – indeed, perhaps even a fundamental requirement of human civilisation.

In recent years, Syrian, Iraqi, Afghan, African, and other migrants from poor and troubled countries have arrived in Europe at historically high levels, providing a challenge to the capacity of European countries to manage the migrants according to normal procedures. In the media and in the public debate, these people have been termed 'migrants', 'irregular migrants', 'refugees', and/ or 'asylum seekers'. These terms are often used synonymously. However, each term refers to a different international definition, and in some cases also to internationally binding conventions and treaties (and thus obligations).

'Migrant' is often used as an umbrella category to denote a person who, temporarily or permanently, moves from one area to another. The term 'migration' implies nothing about the motive or reason for this movement. The vast majority of migration in the world is conducted legally and in accordance with international rules.

On arrival in another country, a migrant must pass through immigration control and, in most cases, will need to have a visa – a permit issued in advance to enter and remain in the country of arrival. Migration that takes place outside countries' visa regulations and the framework regulations of international institutions is called 'irregular migration'.

Irregular migrants have often travelled through a number of transit countries before arriving at their intended destination. Irregular migrants may have fled difficult living conditions in their homeland, in the hope of a better life for themselves and for those members of their families left behind. Such people are also termed 'economic migrants'. (There are also economic migrants who are not irregular migrants.) Even if an irregular economic migrant may have escaped a desperate situation in their homeland, there will often be little chance of the person in question being granted asylum or other form of legal right to stay.

Irregular migrants may also be escaping from armed conflict or persecution in their homeland. These people are often termed 'refugees'. According to the UN Refugee Convention, no refugee may be expelled or returned to a situation in which their life and freedom will be in jeopardy. If an irregular migrant's need for international protection (asylum) is recognised in the arrival country, this person will be granted a residence permit and official refugee status.

In other words, between 'economic migrant' and 'refugee', there is a spectrum of hardships that the person in question has left behind. Any individual irregular migrant may not therefore unequivocally fit into one category or the other. Whatever the underlying motives may be, the term 'irregular migration' covers movement of people that occurs outside the normal, regulated migratory procedures.

Possible developments

The world at present is witnessing hitherto unprecedented flows of irregular migrants, caused by both geopolitical and economic factors that are expected to remain unchanged, or even to deteriorate, over the coming years.

The relative economic prosperity, political stability, and social harmony in Europe still has a great power to attract people from outside (the 'pull factor'). At the same time, political instability (security), climate change, social unrest in the countries of origin, and the lack of economic opportunities, mean that people are being mobilised in a quest to escape their countries of origin (the 'push factor').

The conflicts in Syria, Iraq, and Afghanistan are important reasons for the current rise in irregular migration, and may be expected to continue creating refugees over the coming years. Nor does the conflict in Libya show any signs of improvement, and Libya may therefore remain both a source of migration and a transit country for migrants from West and East Africa.

In addition, there are rises in the numbers of irregular migrants from a number of countries south of the Sahara, which are characterised by failing governance or direct political and social oppression. These countries have poorly functioning institutions that are incapable of safeguarding the citizens' basic needs, which creates a powerful motivating force for migration to better conditions that offer security and the possibility of a better life. Unless improvements are made in these countries in areas such as the economy, corruption, labour market conditions, and fundamental civil rights, it is most likely that the widespread desire to migrate to Europe will persist.

Worldwide, there are more than 55 million refugees (excluding ten million stateless people) who have been driven from their homes. Of these, around 39 million have not yet crossed an international border, but are staying in refugee camps or in another region of their country of origin. Neighbouring regions in the Middle East and North Africa house around 13.5 million of the approximately 16 million international refugees of the world. Turkey alone is home to more than two million refugees from Syria, making it the world's biggest nation in terms of the number of refugees it holds. The 2016 agreement between the EU and Turkey meant there was a large immediate fall in the number of irregular migrants arriving in the EU countries, but it also meant that the number in Turkey grew. At the same time, Lebanon, Jordan, Iraq, and Kenya face substantial challenges managing the millions of refugees whom they are now hosting. It is expected that so-called 'secondary flows of refugees' from areas neighbouring on Europe will attain even greater volumes in the coming years. The reason is that many neighbouring countries appear to have reached their maximum capacities, and that the

people who have sought refuge in these countries have neither the prospects of any normalised living conditions in the foreseeable future, nor the opportunity to travel back home to their countries of origin, which continue to be plagued by conflict.

As well as people escaping from war and persecution, many also leave their country of origin for economic reasons. This may be due to a lack of prospects for work, difficulties accessing essential resources (including land for cultivation), or the absence of an economic safety net. By 2050, the population of Earth will be around 9.6 billion. This represents a growth of two billion people, of whom one billion will grow up in Africa with limited opportunities to achieve their personal ambitions with regard to education and work. One half of the population of the continent is already under the age of 25, and 60 per cent of this group are formally unemployed. Given the population growth, it is likely that the African countries will face major social problems, which may lead to an increase in migration to Europe in the hope of securing a life with better prospects for the future.

In many places in the world, particularly in the world's poorest countries, living conditions may be expected to deteriorate significantly due to climate change. The UN estimates that 20–25 million people have already left their native soil due to climate change. Lack of access to grassland and water have historically been sources of conflict, and it is highly likely that the risk of such conflicts will increase as access to natural resources and land becomes more difficult for the world's poorest people. Climate migration can take place suddenly – as a result of extreme weather – or slowly, when a large number of people choose to leave their country due to deteriorating living conditions, caused by permanent flooding or drought, for example.

Future patterns of migration will thus depend on a large number of socio-economic and political processes, the course and development of which are hard to predict. However, in all probability, urbanisation, climate change, prolonged conflicts, etc., will continue to be contributory

factors in generating the conditions to trigger larger waves of refugees and migrants than we have witnessed to date.

Significance to emergency management

The current refugee crisis gained significant momentum in 2015. This was due to a relatively sudden and persistent rise in the number of irregular migrants arriving in Europe through the Middle East and via the Balkans, and also the fact that large masses from the already overstrained countries in Southern Europe began to move again as they came up through Europe on foot and using land transport. Information sharing via groups on social media meant that, largely speaking, migrants used the same routes, and had the same, relatively few, destination countries in mind. Several of these countries faced challenges to their logistical and administrative ability to deal with the number of incoming migrants.

It is probable that Europe will experience further waves of irregular migration in future. With the large existing foundation for secondary flows of refugees, it is equally likely that the scale of future waves of migration may be larger than we have seen to date.

Major episodic flows of irregular migrants could involve and affect our level of preparedness and emergency management in a number of ways. The proper registration of irregular migrants and the processing of asylum requests require an extraordinary effort on the part of the authorities. There may be a long-term drain on resources, which over time may make it more difficult for the affected organisations to perform other labourintensive tasks.

Whatever the subsequent fate of irregular migrants may be, there will be logistical tasks associated with administering temporary accommodation at centres or in tented camps. This is a further example of what would be a lengthy and labour-intensive task. Experiences from 2015 and 2016 show that, when providing accommodation to irregular migrants, there is also a need to maintain a high level of security. This is due to the risk of racially motivated violence, attempted attacks, arson, or vandalism against the accommodation centres committed by people from extremist backgrounds. Episodes of violence can also erupt internally in the centres as a result of disagreements among the residents, or the general frustrations that the situation may spawn.

At the outer borders of the EU, there is a definite need to tighten up the capabilities and procedures in terms of managing irregular migration. This applies, for example, to border checks, the registration of new arrivals, accommodation, welfare, medical help, and the processing of requests for asylum. There will also continue to be a major requirement for humanitarian rescue actions at sea, with overcrowded boats of irregular migrants continuing to head out on their journey across the Mediterranean.

Both at sea and over land, migration routes regularly change, and new ones may arise in the future. It is not obvious, therefore, which European countries will be particularly sought after refuge countries in future.

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IV.

Increased Activity in the Arctic Region

The Russian tanker Renda sails towards the Port of Nome in Alaska. As the Northwest Passage becomes more navigable, shipping traffic in the Arctic is expected to increase.Image: US Coast Guard

Description

The Danish Realm – Denmark, Greenland and the Faroe Islands – covers a significant and central part of the Arctic. At the moment, the Arctic region is undergoing change in a number of respects, which may also have implications to society as well as in terms of preparedness and emergency management. Changes to the extent and thickness of the sea ice mean that new and larger areas under the jurisdiction and responsibility of the Realm are becoming navigable. This also means an increase in traffic and new activities in these areas.

Politically speaking, a feature of the situation in the Arctic is that extensive work is being done to set up the institutional and practical framework for international coexistence and collaboration in the region. At the same time, the circle of countries and organisations with a direct or indirect interest in the Arctic region is growing.

The focus of the Arctic nations in the Arctic region is on resolving specific problems and continuously establishing and expanding the frameworks for sustainable economic development, including fishing, environmental protection, maritime safety, surveillance, sea rescue, transport and infrastructure. For this reason, recent years have seen a strengthening of the bilateral and multilateral relations between the Arctic nations as far as these areas are concerned.

Changes are also taking place in the Arctic in the economic area. It is likely that the Arctic region in future will generally experience increased economic activity and a rise in investments, while acknowledging that the perspectives and forecasts are subject to significant uncertainty.
The size of the region's economic potential – which is linked, among other things, to new sailing routes and tourism, as well as oil, gas and mineral extraction – is dependent not only on a reduction in the extent of the ice but also on external factors, such as global raw materials prices and technological development. At the same time, a stable political trend in the Arctic is a prerequisite for realising the full economic potential of the region.

Along with the Faroese and Greenlandic authorities, the Danish Armed Forced (Danish Defence) takes charge of a range of important civilian tasks in the Arctic regions of the Realm. These include search and rescue services, protection of the marine environment and fishing vessel inspections. This is due to the fact that Danish Defence traditionally has had the necessary capacities at its disposal to operate in the Arctic regions, in accordance with its central tasks of sovereignty enforcement, military defence and surveillance in Greenland and the Faroe Islands.

Possible developments

Large parts of the Arctic area are both environmentally fragile and inhospitable to humans. Nonetheless, Denmark has joint responsibility for the development, management and resolution of issues in the Arctic. This applies both in terms of the region's sustainability and with regard to the many different players travelling in the region, particularly within or close to the territory of the Danish Realm.

To the extent that economic activity in the Arctic continues to increase, there will also be risks to the environment, population and fauna of the region. The extent of these risks will depend on the specific development of, for example, mining and sailing routes. This will place greater demands on the ability of the Danish Realm to contribute to greater surveillance, broader societal security and an increased level of preparedness in the region.

The sailing routes from Europe to North East Asia along the northern coast of Russia (the 'Northeast Passage') and from the Atlantic to the Pacific north of Canada (the 'Northwest Passage') have become profitably navigable during the summer period. Due to the low price of oil, among other things, traffic through these passages has nonetheless been at a low level in recent years. However, given the developments in world trading, there is a potential for this traffic to increase many-fold, whether measured in tonnage or the number of vessels.

There are particular challenges associated with navigation at sea in the Arctic. Ice of many different types occurs, which can damage a ship's hull. Some types of drift ice lie so low in the water that they can be very difficult to spot. Furthermore, as the extent of the sea ice contracts, there will be new routes and coastlines that have not yet been surveyed and charted, along which there may also be hitherto unknown rocks. The extent of the ice even changes with the seasons, so that, for example, depths and sailing routes can hardly be marked on permanent marine charts. The increase in shipping in the Arctic regions is thus accompanied by an increased basis of risk of grounding and shipwrecks.

A feature of the current developments in the Arctic is economic progress and international cooperation. It is possible that the political climate in future may be affected by the failing trust between Russia and the West as a result of the Ukraine crisis and Russia's illegal annexation of the Crimea peninsula. However, the current deterioration in political relations between Russia and the West does not – for the moment at least – appear to be having any impact as far as the Arctic is concerned, and the immediate likelihood appears to be that an environment will continue to prevail in the region that is characterised more by cooperation and competition than by confrontation and conflict.

The Danish Armed Forces will continue to play an important role in the Arctic. Although the focus on foreign policy and the military presence in the Arctic has generally increased, it is important to point out that Danish Armed Forces' units in the Arctic also address and perform central civilian tasks in the area, including those relating to emergency management. Any increased Danish military presence in the Arctic area will not be an indication of a militarisation of the area, as to a large extent this presence will be there to perform civilian tasks in the area.
It may be a task in itself to communicate this clearly to the other Arctic coastal nations.

Significance to emergency management

Including the Faroe Islands and Greenland, the Danish Realm has a total of more than 45,000 kilometres of Arctic coastline. Eighty per cent of the area of Greenland is covered by a permanent icecap and glaciers, and in a territory of over two million km^2 the road network amounts to just 150 km, less than half of which is metalled. The infrastructure conditions limit the number of people that can be supported at the same time from a logistical point of view.

Carrying out assignments in the Arctic environment is both difficult and costly. The large distances and difficulties reaching some regions in themselves can present problems, for example when performing rescues. Not only that, but some otherwise familiar incident types can take on a very different character when they occur in the Arctic environment. In particular, with the need to find shelter from the cold and the long travelling times, the reality faced by the emergency management services is very different indeed. For example, a large number of civilian flights between the continents fly over Arctic airspace every day. Even though the likelihood of an aircraft having an accident in the Arctic regions is not immediately greater than elsewhere, it would be significantly more difficult to locate and rescue any crash survivors in time.

Both the Faroe Islands and Greenland are experiencing a significant rise in the number of tourists visiting them. This also applies to the number of cruise ships operating in the Arctic. In the summer of 2016, the first cruise ship sailed through the Northwest Passage from Vancouver in Canada to New York on the USA's east coast, with around 1,700 people on board. For several hundred kilometres, the cruise ship's route took it along the west coast of Greenland, and the company behind the cruise is planning to run similar tours in the coming summers. However, at present no country has sufficient capacity to launch an effective sea rescue of people on that scale in the Arctic. Furthermore, with shipwrecks involving industrial vessels, there may be a risk of a spillage of bunker oil or other chemicals. The

prospect of offshore oil extraction in the Arctic regions introduces the risk of major environmental pollution in these areas. Not only will the factors discussed above make it significantly more difficult to manage a major environmental pollution event, at the same time the environmental consequences could turn out to be more serious. Arctic ecosystems are probably more vulnerable to oil pollution than others, while at the same time nature's own biological breakdown process of the oil takes place much more slowly in the cold temperatures.

Taken together, the increase in tourism and commercial maritime activity such as shipping and tourism, the rise in research activity and activities relating to the extraction of raw materials, will contribute to a greater basis of risk in the Arctic. When seen alongside the sparse infrastructure that has traditionally been aimed at the fairly small local population, this all points to a marked challenge in terms of maintaining an adequate level of civilian preparedness in the Arctic.

The approach taken by the Danish Realm to performing tasks in the areas around the Faroe Islands and Greenland, i.e. primarily centred around a single organisation, is basically an effective use of society's resources. However, there will be an increased need in future for greater commitment and cohesive thinking in the Arctic if an effective level of civilian preparedness is to be maintained in all parts of the Danish Realm.