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A Danish terminological ontology of incident management in the field of disaster management

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Abstract

Lack of concept clarification based on concept modelling results in inappropriate term use and inefficient information and communication technology. In this contribution, we refer to the fire aboard the ship Scandinavian Star in 1990 and the terror attack at Utøya in 2011 as examples. We establish a terminological ontology for 46 Danish concepts included in an alphabetically organized term list on incident management by the Danish Emergency Management Agency (DEMA). Based on this ontology, the main aim is to demonstrate how terminological principles may form the basis for creating structured data, which may support a common understanding of domain-specific key concepts which again is a prerequisite for successful and well-functioning disaster management systems. The terminological method will be explained, focusing on terminological ontologies and terminological definitions reflecting the semantic structure of the domain. Further, we illustrate the use of technology for knowledge modelling and sharing, and we briefly describe how the results of terminology work may be stored in a term bank in order to support common understanding and efficient communication. Moreover, terminological ontologies may lay the foundation for data models for disaster management systems, technologies involving Artificial Intelligence, and building blocks of semantic technologies.

KEYWORDS
incident management, crisis communication, concept clarification, terminological ontologies, definition writing, disaster management systems, data models, interoperability

1 | INTRODUCTION

This paper focuses on the principles and methods of terminological knowledge modelling, which aim at structuring and defining domain-specific concepts in the form of terminological ontologies, thereby obtaining a clarification and common understanding of the concepts of incident management. We give examples of how the lack of concept clarification results in ambigous and inappropriate term use and inefficient Information and Communication Systems. Further, we illustrate how technology for knowledge modelling and knowledge sharing may be used as a tool for production and exchange of knowledge intended for the various types of stakeholders in disaster risk management. Finally, we discuss how a terminology and knowledge bank may serve as an efficient tool for access to terminological ontologies comprising information on concepts and their definitions, and we mention how terminological ontologies may

constitute the first step in data modelling and thus in developing IT systems (Madsen & Thomsen, 2015: 250–275), and how they may be useful for Artificial Intelligence (Dansk Sprognævn, 2019).

One of the first steps in terminology knowledge modelling is to identify terms and contexts comprising them. In the proceedings of DIMPLE: DIsaster Management and Principled Large-scale information Extraction (Ahmad & Vogel, 2014), research on corpus-driven term extraction and the use of term extraction methods and tools is introduced in several contributions. We refer to Zhang and Khurshid (2014) as well as to Madsen and Thomsen (2014). Zhang and Khurshid (2014) outline a corpus-based method for building the ontology and terminology of natural disasters. Madsen and Thomsen (2014) describe their work on terminological ontologies for risk and vulnerability analysis as well as methods and prototype tools for automatic term extraction and automatic ontology construction, which have been developed by researchers at Copenhagen Business School (CBS). A similar approach to information extraction is seen in the article "Battle Management Language as "Lingua Franca" for Situation Awareness" (Rein & Schade, 2012). We did not need term extraction tools in our present study, since we have based it mainly on a publication by the Danish Emergency Management Agency, DEMA, (Beredskabsstyrelsen, 2018). For information on automatic term extraction, we therefore refer to the above-mentioned publications.

In what follows, we use the guidelines for incident management in the above-mentioned publication (Beredskabsstyrelsen, 2018) as a case study and refer to recent Norwegian terminology studies on disaster events (*Section 2. Background*). The target group of the guidelines related to incident management includes especially the police, the fire and rescue service, the health service, and other actors in the preparedness services (Beredskabsstyrelsen, 2018: 7). The preface of the guidelines stresses that in Denmark a strong tradition exists of close cooperation and interdisciplinary coordination when authorities and preparedness services participate in preparedness activities. Thus, the aim of the guidelines is to secure efficient management and cooperation where all persons involved in the activities know and adhere to the main principles agreed on. The guidelines apply to all types of preparedness activities, regardless of the nature and scope of the events, and cover both events of common occurrence such as fire and major events such as terrorist incidents (Beredskabsstyrelsen, 2018: 1, 7). The guidelines include a term list of 46 Danish concepts within the domain of disaster management. The analysis of these 46 concepts should be understood as a point of departure for further terminology work within the subject area of disaster management.

Thus, related to the guidelines of incident management, the main aim of this contribution is to demonstrate how terminological principles are useful when creating structured data, which may form a helpful tool to ensure a common understanding and interoperability between IT systems. After a short description of the background, *Section 2. Background*, we introduce the principles of terminological ontologies compared to traditional concept systems, as well as basic principles of terminological ontologies, *Section 3. Methodology*. Then, we will illustrate how to establish a Danish terminological ontology

for the concepts included in the term list (Beredskabsstyrelsen, 2018: 64–70), *Section 4. An Ontology of Incident Management*. In our work, we use the graphic module of a terminology management system. Next, based on the ontology established and the explanations found in the term list, the aim is to show how these explanations may be rewritten into genuine terminological definitions reflecting the semantic structure and the conceptual relations of the domain (ISO 704, 2009: 22–23), *Section 5. Rewriting Explanations into Extensional Definitions*. Finally, the objective is to store the results of the terminology work in a terminology and knowledge base, *Section 6. Terminological Resources*. In *Section 7. Conclusion*, we will touch upon some perspectives related to the use of terminological ontologies as a foundation for data models, user interfaces and Artificial Intelligence.

Out of regard for readers without knowledge of Danish or Norwegian, in the article English translations in italics are placed before the original Danish or Norwegian terms in parenthesis.

2 | BACKGROUND

In publications on disaster management communication by DEMA, the focus is on preparedness for crisis communication. The aim of these publications is to clarify the responsibility for the communication and to lay down procedures for informing the public sector, the media and the citizens in order to mitigate the consequences of major extraordinary events. The reason is that such events call for a different organizational communication than the one used in day-to-day operations (Beredskabsstyrelsen, 2018: 43; Beredskabsstyrelsen, 2016; Beredskabsstyrelsen, 2005).

It appears that the publications mentioned above all refer to the organization of external communication. However, Norwegian terminology studies on disaster events have demonstrated that as far as internal communication among a number of Norwegian preparedness services is concerned, an overlap exists among concepts used by the various services (Aasgaard, 2017: 83). In addition, the studies showed that various services do not apply the same terms for the same concepts. This varying term use results in inconsistent terminology, which hinders efficient communication and interoperability between IT systems. In particular, the Norwegian studies identified the problem in organizational and administrative terminology, for example related to subdivision of an area into zones (Aasgaard 2017: 84). According to Aasgaard, it may be difficult to identify the differences between closely related terms referring to the scenes related to an accident or event such as *site of damage* (skadested), *area of danger* (fareområde), *crime scene* (åsted) and *scene of accident* (ulykkessted). The Norwegian studies resulted in a handbook for rescue service (Hovedredningssentralen, 2018). Moreover, an official report on the terror attacks in Oslo and at Utøya on 22 July 2011, Rapport fra 22. juli-kommisjonen (Departementenes servicecenter, 2012) refers to communication problems among several participants (services). Consequently, the participants did not find each other.

In addition, the report mentions informal language as a problem (Aasgaard, 2017: 84; Departementenes servicecenter, 2012: 453). One of the conclusions of the report was that the use of Information and Communication Technology was of poor quality.

In their introduction, Elmhadhbi et al. (2020) also stress that numerous reports from major disasters (e.g., 11 September and 13 November terrorist attacks) refer to communication difficulties among various actors such as firefighters, police, healthcare services which may lead to a break down at the operational response since each actor has its own technical vocabulary. As a result, this discrepancy of information leads to a misunderstanding, a deficiency of semantic interoperability and lack of information sharing among the different actors.

Further, in 1990, a fire aboard the ship Scandinavian Star killed 159 people. The official report refers to inconsistent term use as far as job titles were concerned, which may have led to misunderstandings within the lines of command (Government Administration Services, Government Printing Services, 1991: 104). Thus, it stands to reason that lack of concept clarification resulting in inappropriate term use and inefficient Information and Communication Systems impedes the response to emergency situations.

Similarly, in his article "Crisis and Disaster Management Terminology," Stoyanov (2017) addresses the lack of consensus in academia and among the different institutions concerning main terms and definitions in the field of crisis and disaster management terminology. According to Stoyanov, no document is available in which all main crisis and disaster management concepts are defined in a "clear and logically connected manner." Even in the draft version of United Nations International Strategy for Disaster Reduction (UNISDR, 2016), which he categorizes as a good example, he has identified discrepancies and overlap. He ascribes this to the fact that no one has tried "to connect terms with each other."

In the light of the above results, in this study we focus on concept clarification of central concepts included in the term list in the Danish publication by DEMA on incident management (indsatsledelse) (Beredskabsstyrelsen, 2018: 64–70), see *Section 1. Introduction*. We apply the terminological method since concept clarification is the backbone of all terminology work, see *Section 3.1 Terminological Method*.

In spite of the fact that some of the terms in the list are not considered to be very specialized, these "grey zone" terms still belong to the specialized vocabulary of disaster management; examples are *site of damage* (skadested) and *crime scene* (gerningssted). Most people have a common understanding of these terms, whereas they do not know the domain specific, professional meaning of these central concepts when used by practitioners in disaster management. The term list standardizes key incident management terms that are necessary to assist disaster management practitioners from various preparedness services cross-disciplinarily. In short, the aim of the list is to support clear understanding of common concepts and efficient communication in concrete work situations. In this study, we do not deal with the terminology of

UNISDR (2016), since our focus is on incident management, and not on disaster risk reduction. We define incident management as "management coordinating the actions of personnel and resources across services necessary to manage disasters and emergencies." In addition, we do not deal with terms normally associated with disaster management such as *hurricane*, *tornado*, *flood*, *earthquake and explosion*.

3 | METHODOLOGY

3.1 | Terminological method

Below, we will give a general introduction to the concept systems and definitions applied in terminology work. The terminological method helps to clarify concepts within specific domains and to develop terminological concept systems showing the relations among (closely related) concepts. The conceptual relations are subdivided into generic and partitive relations (both of which are hierarchical relations) and associative relations. In concept systems with hierarchical relations, the concepts are organized as superordinate and subordinate concepts (ISO 704: 8). In type of relations, also called generic relations, the subordinate concepts inherit the characteristics of the superordinate concepts. In part–whole relations, also called partitive relations, the superordinate concept (comprehensive concept) represents a whole, whereas the subordinate concepts (partitive concepts) represent the parts which constitute the whole (ISO 704, 2009: 13). Part–whole relations are not logical relations, and in part–whole relations, there is no inheritance of characteristics. Associative relations are non-hierarchical and exist between concepts that have a thematic connection (ISO 704, 2009: 17), for instance cause–effect relations. Traditionally, concept systems are presented as tree diagrams (Nuopponen, 2016: 191). The concept systems may combine the various types of relation. In *Section 3.2 Basic Characteristics of Terminological Ontologies* and Section *3.3 Principles Governing the Structure of Terminological Ontologies*, we will go one step further and introduce terminological ontologies that are enhanced concept systems.

Based on concept systems, one may compile brief and consistent definitions. The intensional definitions applied in terminology work start by introducing the term designating the superordinate concept (the genus proximus), followed by the differentiating characteristics (the differentia specifica) only. In this way, the intensional definition indirectly comprises the characteristics inherited from the superordinate concept and the characteristic that delimits a specific concept from both its superordinate and its coordinate concepts (Thomsen, 2017). Thus, the intensional definition has a formal structure as shown below:

definiendum (the term for the concept to be defined) definitor (=) genus proximum (the immediate superordinate concept) + differentia specifica (the differentiating characteristics)

The consistent and precise way of formulating intensional definitions helps to identify concepts and to place them correctly in

concept systems (Thomsen, 2017; Suonuuti, 2001: 19). The intensional definition is also referred to as the Aristotelean definition. The extensional definition is another type of definition used. In these definitions, the immediate superordinate concept is followed by a list of subordinate concepts (ISO 704, 2009: 44; Suonuuti, 2001: 21). Generally, extensional definitions are recommended only when it possible to list all subordinate concepts, and the subordinate concepts are well known (ISO 704, 2009: 44). In terminology work, sometimes extensional definitions are applied as supplementary definitions. In addition, terminology work also helps identify synonyms and to select a preferred term among synonyms.

3.2 | Basic characteristics of terminological ontologies

Terminological ontologies have their roots in terminology work, which primarily aimed at facilitating understanding in human communication. As described in *Section 3.1 Terminological Method*, in traditional terminological concept systems, knowledge is modelled as concepts and relations among them, see, for example ISO 704 (2009). Terminological ontologies are enhanced concept systems, in which characteristics of concepts are included as formal attribute–value pairs, and formal rules related to the inheritance of characteristics enable validation, which is not possible in general concept systems.

The principles of terminological ontologies are based on the formalization of concept characteristics according to typed feature theory (Carpenter, 1992) and imply a number of specific constraints which aim at ensuring consistent ontologies and thus a consistent representation of a given domain of knowledge. The core principles of terminological ontologies were developed by a group of researchers at Copenhagen Business School (CBS) in the project Computer-aided Ontology Structuring, CAOS (1998-2007), which aimed at semi-automatic development and validation of ontologies (Madsen, 2006; Madsen et al., 2004), see *Section 3.3 Principles Governing the Structure of Terminological Ontologies*.

In Figure 1, we use the extract of an ontology as an example of a terminological ontology, which has been created using the graphic module of the terminology management system i-Term (Madsen, 2006), (DANTERM technologies, https://www.danterm.dk/). I-Term is the only terminology management system, which includes a graphical module specifically designed to handle terminological ontologies. The example is adapted from (Madsen & Thomsen, 2014). The basic characteristics of terminological ontologies are illustrated in Figure 1. Here, the yellow boxes represent concepts with characteristics written below them, and the green lines represent type relations (generic relations) between concepts, whereas the white boxes represent subdivision criteria. By using attribute–value pairs as the representation of characteristics, their relationship with subdivision criteria becomes apparent. The subdivision criterion corresponds the attribute of the delimiting characteristic of concepts falling under that criterion.
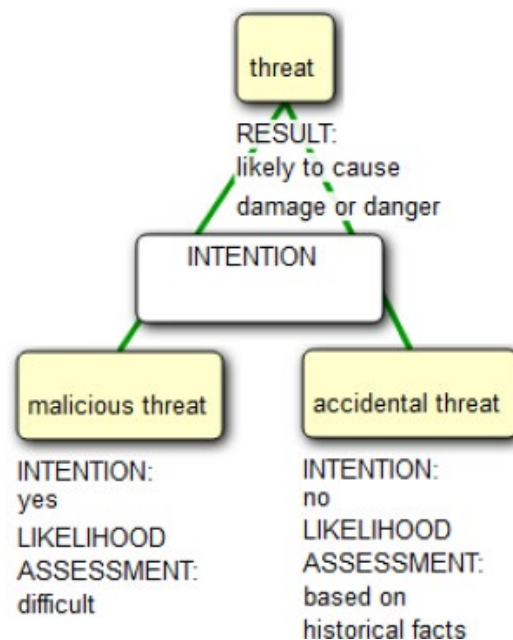

FIGURE 1 Example of an extract of a terminological ontology [Colour figure can be viewed at wileyonlinelibrary.com]

3.3 | Principles governing the structure of terminological ontologies

The most important principles governing the structure of terminological ontologies are described in (Madsen, 2006; Madsen & Thomsen, 2015; Madsen et al., 2004). In what follows, we focus on the following central principles:

1. uniqueness of dimensions
2. grouping by subdivision criteria (choice of subdivision criterion)
3. uniqueness of "primary" characteristics (i.e., non-inherited characteristics)
4. no overlap of subdivision criteria.
5. The principle of uniqueness of dimensions specifies that a given dimension may only occur in one place in the ontology. In a terminological ontology on printers, *SIZE* may occur in two places. In this case, two dimensions: *PAPER SIZE* and *PRINTER SIZE* should be introduced. In other cases, the ontology needs to be changed. The principle implies that concepts characterized by means of primary characteristics with the same attribute must be coordinate concepts (sisters), sharing the same immediately superordinate concept. In this way, the principle assists in creating coherence and simplicity in the ontological structure. The adherence to this principle may sometimes cause problems. If the ontology is used as a basis for concept clarification, it may be less important. However, if a terminological ontology is used as a basis for data modelling, one should adhere to it.
6. At every level of subdivision, one dimension must be chosen as the subdivision criterion. When working with the various types of *threat*, one may record several characteristics, for example those shown in Figure 1. In this case, *INTENTION* has been chosen as the

subdivision criterion since the other dimension is dependent on this. Subdivision criteria provide a good overview and assist the terminologist in writing consistent definitions.

7. The principle of uniqueness of primary characteristics specifies that a given characteristic can only be introduced as primary on one single concept in the ontology. This implies that all concepts sharing the same characteristic must be located on the same branch of the ontology, in order to inherit the characteristic in question from the same concept at some superordinate level. In Figure 1, the concept *threat* has the primary characteristic *RESULT: likely to cause damage or danger*. The two subordinate concepts inherit this characteristic. In terminological ontologies, we normally only present primary, delimiting characteristics. Thus, the two concepts *malicious threat* and *accidental threat* will only be presented with the characteristics *INTENTION: yes* and *INTENTION: no*, respectively.

8. Finally, subdividing dimensions are not allowed to overlap, that is a situation such as the one illustrated in Figure 2 is not allowed. In this case, a polyhierarchy must be constructed by introducing two additional concepts (*accidental threat* and *pre-warned threat*). The concept *accidental pre-warned threat* may then be related to two superordinate concepts falling under two different subdivision criteria, as shown in Figure 3. A concept in a polyhierarchy may be characterized by the combination of characteristics of the superordinate concepts.

Compared to other ontologies, a terminological ontology describes specific concepts, it has a specific purpose (concept clarification), it represents the concept system of a specific domain, and it is based on a specific paradigm (typed feature structures).

Sinha and Dutta (2020: 147–151) describe fourteen flood ontologies using twelve parameters, one of which is design methodology for the ontologies. They conclude that only few principles exist, but among these "METHONTOLOGY is the preferred one as it is a structured, generic, and application-independent approach method for building ontologies from scratch ..... This methodology consists of five main steps of development activities: specification, conceptualization, formalization, implementation, and evaluation." For example, Elmhadhbi et al. (2020) used METHONTOLOGY in the POLARISCO project. METHONTOLOGY and the methods and principles of terminological ontologies, as described in this chapter, are similar in many ways, although more IT tools are available for the METHONTOLOGY activities implementation and evaluation.

Another parameter described by Sinha and Dutta (2020: 150) is representation language. According to their investigations, a majority of the ontologies were developed using OWL, a formal language for representing information making it ready for machine processing recommended by W3C. According to Elmhadhbi et al. (2020), the consistency of POLARISCO modules was checked using the reasoner HermiT, which is an OWL2 reasoner included in Protégé. The terminological ontologies, described in this chapter do not use a formal ontology language such as OWL. Their main purpose is to obtain concept clarification and mutual understanding of the concepts of a specific domain. Our ontologies may be characterized as semiformal according to Sinha & Dutta (2020: 150). They are feature-based, and the contents may form the basis for a formal ontology.

4 | AN ONTOLOGY OF INCIDENT MANAGEMENT

4.1 | Input to the ontology

The Ontology of Incident Management comprises the concepts from the list of terms and explanations included in (Beredskabsstyrelsen, 2018: 64–70). We also included a number of general concepts which
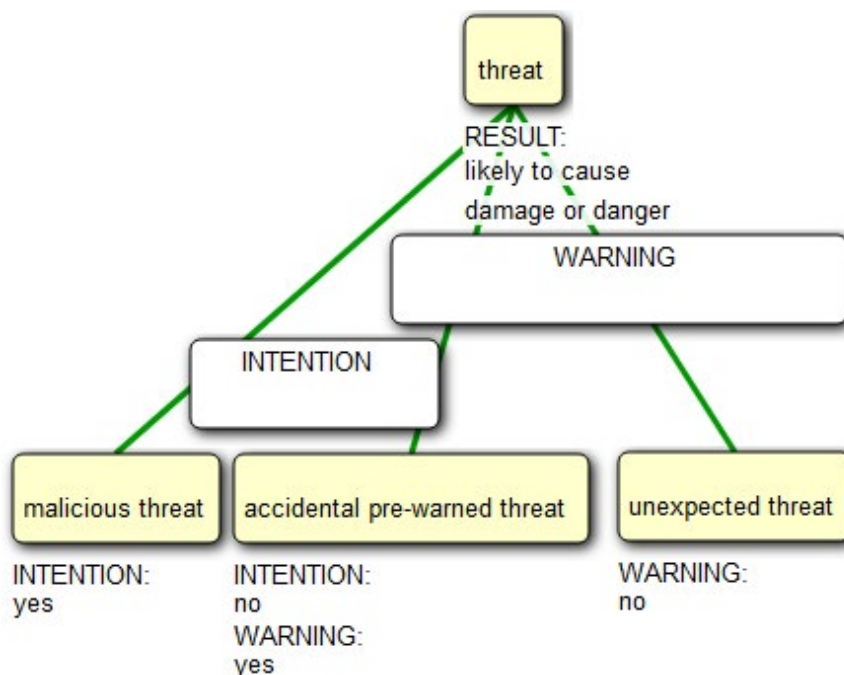

FIGURE 2 Overlapping subdivision criteria [Colour figure can be viewed at wileyonlinelibrary.com]
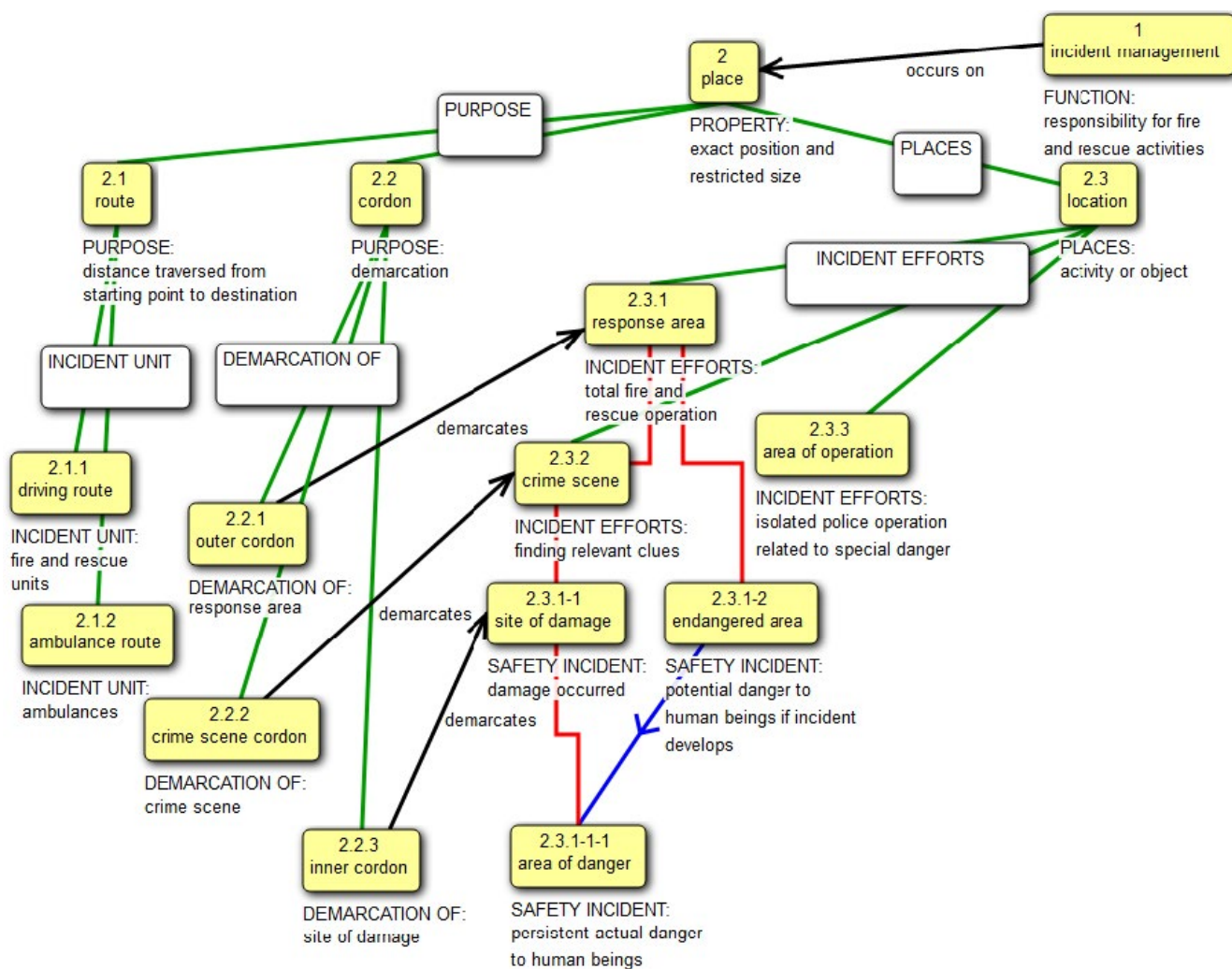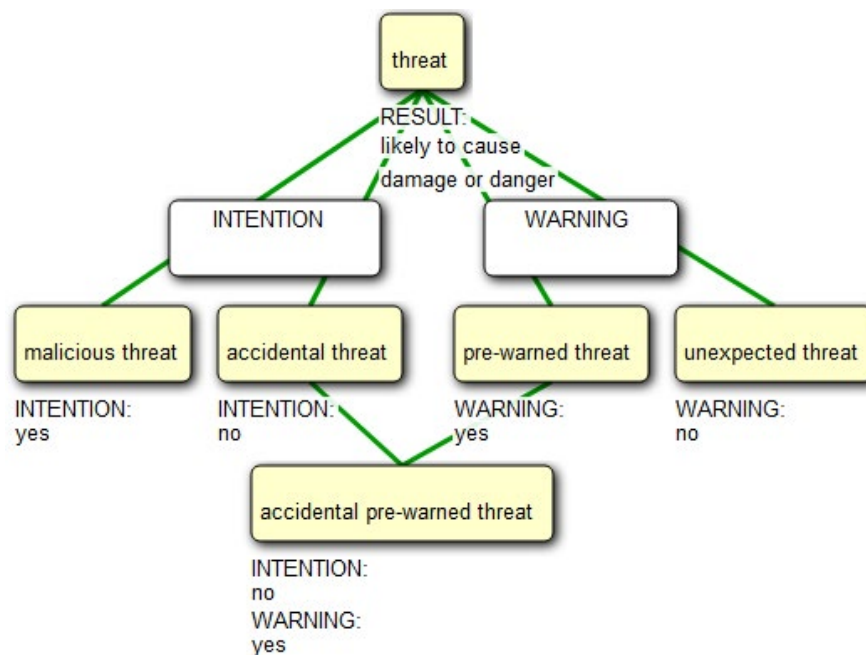
FIGURE 4 The Ontology of Place Part one [Colour figure can be viewed at wileyonlinelibrary.com]

were necessary in order to group the 46 domain-specific concepts. The total ontology of *place*, *agent*, *activity* and *time* (sted, aktør, aktivitet and tid) currently comprises 66 concepts. In *Section 4.2 The Ontology of Place*, we focus on the concepts under the general concept *place*. In the ontologies, the Danish concepts are represented by English glosses, that is they are not intended to show the reality nor the terminology of an English speaking environment. Normally, we would develop an ontology comprising the English concepts in parallel to the Danish ontology and then compare the two ontologies in order to identify cases of partial or non-existing equivalence. The English ontology may reveal cultural differences, which would result in different concepts and relations.

4.2 | The ontology of place

Figures 4 and 5 each shows a part of the *Ontology of Incident Management*, that is the concepts grouped under the general concept *place* (*sted*) (in the following referred to as the *Ontology of Place*).

The *Ontology of Place* comprises a total of 28 concepts, five of which are general concepts: *place*, *route*, *cordon*, *location* and *locality* (sted, vej, afspærring, lokation and lokalitet), which were introduced by the authors in order to be able to group the domain-specific concepts. We use Figure 4 to further explain the conceptual relations used in a terminological ontology. We have chosen the concept *location* (lokation) instead of the concept *area* (område), because the concept *location* (lokation) has the definition "place in which something happens or is situated" (sted hvor noget sker eller er beliggende) (DANTERMcentret, 2013), whereas *area* (område) has various other meanings.

Type relations (represented by green lines) can be explained by means of the logical inclusion relation. From an extensional point of view, the set of referents of the subordinate (specific) concept is a proper subset of the referents of the superordinate (generic) concept. From an intensional point of view, however, the set of characteristics of a given superordinate concept is a proper subset of the characteristics of its subordinate concepts. Subordinate concepts inherit the characteristics of a superordinate concept.
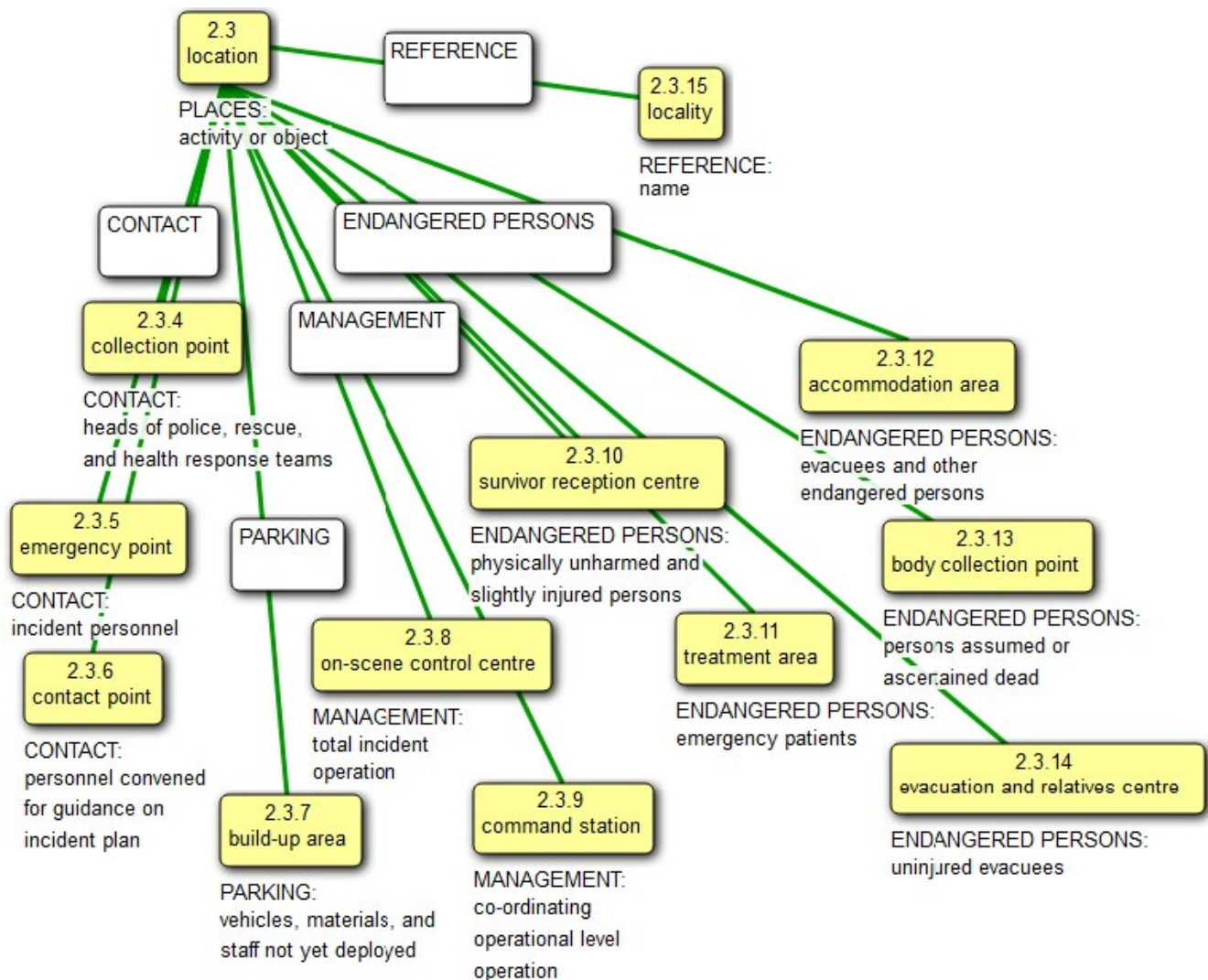

FIGURE 5 The Ontology of Place Part two [Colour figure can be viewed at wileyonlinelibrary.com]

Part–whole relations (partitive relations, represented by red, broken lines) differ from type relations in that they are not logical inclusion relations. The set of characteristics of a subordinate (partitive) concept is not a proper subset of the set of characteristics of the of its superordinate (comprehensive) concept. Partitive concepts do not inherit the characteristics of a comprehensive concept.

In Figure 4, which represents Part 1 of the *Ontology of Place*, red lines correspond to part–whole relations. Based on (Beredskabsstyrelsen, 2018), we consider *site of damage* (skadested) and *endangered area* (truet område) to be parts of *response area* (indsatsområde). Associative relations are represented by a black line, with indication of direction and a label, for example the relation *demarcates* (afgrænser) between *outer cordon* (ydre afspærring) and *response area* (indsatsområde) as well as between *inner cordon* (indre afspærring) and *site of damage* (skadested). Finally, temporal relations are represented by a blue line with an arrow, for example the relation between *endangered area* (truet område) and *area of danger* (fareområde), that is an *endangered area* may develop into an *area of danger*.

The concept *response area* (indsatsområde) is a type of *location* (lokation), and it inherits the characteristic *PLACES: activity or object* (PLACERER: aktivitet eller objekt) from this superordinate concept. It was not easy to identify the subdivision criteria which might serve to differentiate the concepts under the concept *location* (lokation) in the best way possible. Based on our preliminary groupings, it seemed that five groups were needed. We have chosen *INCIDENT EFFORTS, CONTACT, PARKING, MANAGEMENT and ENDANGERED PERSONS* (INDSATS, KONTAKT, PARKERING, LEDELSE and NØDSTEDTE), see Figures 4 and 5. In Figure 4, the characteristic *INCIDENT EFFORTS: total fire and rescue operation* (INDSATS: samlet beredskabsmæssig indsats) differentiates *response area* (indsatsområde) from the coordinate concepts *crime scene* (gerningssted) and *area of operation* (operationssområde), which have the characteristics: *INCIDENT EFFORTS: finding relevant clues* (INDSATS: politimæssig indsats mhp. at finde konkrete spor) and *INCIDENT EFFORTS: isolated police operation related to special danger* (INDSATS: isoleret politimæssig indsats ved særlig fare), respectively.

Figure 5 presents Part two of the *Ontology of Place* comprising the concepts under the subdivision criteria *CONTACT, PARKING, MANAGEMENT, and ENDANGERED PERSONS* (INDSATS, KONTAKT, PARKERING, LEDELSE and NØDSTEDTE), as well as the concept *locality* (lokalitet) with the characteristic *REFERENCE: name* (REFERENCE: navn). We have included the characteristics of *location* (lokation) and *locality* (lokalitet) from earlier ontologies established by the Danish Forum for Knowledge Modelling in the Public Sector, FORVIR, and DANTERMcentret (2013).

In the explanations of some concepts in (Beredskabsstyrelsen, 2018), the concept *locality* is mentioned as the superordinate concept. In some of the explanations of these concepts, *locality* (lokalitet) is mentioned together with other superordinate concepts, *building* (bygning) and *area* (område). This fact complicates the ontology work. Moreover, it is not entirely clear what the definition of *locality* (lokalitet) would be in (Beredskabsstyrelsen, 2018). Normally,

the combination of two superordinate concepts may be confusing and should be avoided in intensional definitions, unless a concept has two superordinate concepts (polyhierarchy). Examples in Table 1 are found below.

4.3 | Top Level of the Ontology of Incident Management (Indsatsledelse)

In order to provide an overview, Appendix 1 presents the top level of the Ontology of *Incident Management*. We have chosen the concept *incident management* (indsatsledelse), in the meaning *activity*, as the concept which links the general concepts *place, agent, activity* and *time* (sted, aktør, aktivitet and tid). The relations are associative, for example *incident management occurs at a place* (indsatsledelse foregår på sted). Whether this is the best solution is open to discussion since the same concept, *incident management* (indsatsledelse), might also be subordinate to the general concept *activity*. A further problem arises in that the designation *incident management* (indsatsledelse) is a homonym (having two meanings, i.e. activity and agent). The concept *incident management* (indsatsledelse), in the meaning *agent*, is found under the general concept *agent* (aktør). Characteristics of the concepts *agent* and *activity* originate from the ontology of general concepts created by a working group under the FORVIR network comprising common public concepts. The characteristics (and definitions) of the concepts *activity* (aktivitet) and *event* (begivenhed) are abstract and not very self-explanatory; therefore, supplementary information is added. They are derived from the upper general level of the FORVIR ontology, which is based on DOLCE, Descriptive Ontology for Linguistic and Cognitive Engineering, (http://www.loa.istc.cnr.it/old/Papers/DOLCE2.1-FOL.pdf).

5 | REWRITING EXPLANATIONS INTO INTENSIONAL DEFINITIONS

In terminology work, one may use various types of descriptions of concepts. The choice of description depends, among other things,

TABLE 1 Explanations from (Beredskabsstyrelsen, 2018)

Concept:	Explanation from (Beredskabsstyrelsen, 2018):
area of danger (fareområde):	*The <u>area</u> or the <u>locality</u> (Det <u>område</u> eller den <u>lokalitet...</u>)*
accomodation area (indkvarteringsområde):	*An <u>area</u> or a <u>locality</u> (Et <u>område</u> eller en <u>lokalitet</u> ...)*
evacuation and relatives centre (evakuerings- og pårørendecenter):	A <u>building</u> or another weather-resistant <u>locality</u> ... (En <u>bygning</u> eller anden vejrbestandig <u>lokalitet</u> ...)
command station (kommandostation):	*The <u>locality</u>, typically at a police station (Den <u>lokalitet</u>, typisk på politistationen ...)*

Underlines mark the superordinate concepts in the explanations.

on the target users, whether they are human beings (laymen or experts), or computers. Though this is not the best choice, quite often descriptions and not genuine definitions are recorded in terminology bases. This is often the case if no concepts systems have been developed. However, according to the central ISO standard of terminology, ISO 704 (2009: 22), traditional intensional definitions are "the most explicit and precise method of concept definition." Moreover, the main purpose of intensional definitions is to differentiate the concept in question from related concepts (ISO 704, 2009: 22; ISO 1087, 2000: 6; Thomsen, 2017). A definition should describe one concept only (ISO 704, 2009: 28). Thus, the purpose of intensional definitions is not to convey more information than the superordinate concept and the differentiating characteristics. More detailed knowledge on concepts is found in supplementary descriptions such as notes and encyclopedic descriptions. Notes may include supplementary characteristics of concepts, optional parts or elements referring to the extension of the concept. Encyclopedic descriptions, on the other hand, often include the characteristics needed for the intensional definitions and thus may provide input for the definitions, but they also provide more detailed knowledge about the concept not needed for the intensional definitions (ISO 704, 2009: 29).

Below, we explain how to rewrite explanations included in the term list (Beredskabsstyrelsen, 2018: 64-70) into clear and consistent terminological definitions on the basis of the concept relations and subdivision criteria in the *Ontology of Incident Management*, see Figure 3 *The Ontology of Place*. As mentioned in *Section 4.2 The Ontology of Place*, subdivision criteria give a good overview and help the terminologist in writing consistent definitions. The rewriting of the explanations will be exemplified by definitions for subconcepts of the concept *location* (lokation). We have chosen these concepts since they are central concepts explained in the introduction of the publication by Beredskabsstyrelsen (2018).

Table 2 *Rewriting explanations into intensional definitions* is part of a systematic list generated from the terminology management system i-Term. It comprises the concepts chosen, the notations indicating the position of the concept in the terminological ontology, and the attribute–value pairs of the concepts that we have identified during our work. Moreover, the list presents the explanations from the term list and the definitions proposed by us.

The concepts *response area*, *crime scene* and *area of operation* (indsatsområde, gerningssted and operationsområde) are coordinate concepts and all immediate subordinate concepts of the concept *location* (location) in a type relation. Therefore, the intensional definitions that are based on type relations start with the term designating the immediate superordinate concept which is *location* (location), see *Section 3.1 Terminological Method*.

As for the differentiating characteristics, the three concepts are placed below the subdivision criterion *INCIDENT EFFORTS* (INDSATS) indicating the type of effort taking place in a specific area in case of an incident.

Most of the explanations in the term list are very similar to encyclopedic descriptions. They do somewhere in the text include the term for the superordinate concept *area* (område), and the

differentiating characteristic, see the words underlined. In the definitions, we have chosen *location* (lokation) instead of *area* (område), see discussion in *Section 4.2 The Ontology of Place*. However, the explanations do not obey the format of intensional definitions, and they are all very long and include supplementary information. In terminology work, definitions are written in one sentence with lower case letters and without punctuation.

As for the explanation of the concept *response area* (indsatsområde), the last two sentences of the explanation relate the concept to other concepts in the ontology, namely *outer cordon* (ydre afspærring) and *site of damage* (skadested). This information does not belong in the definition, but is evident from the ontology or may be added in a note in the terminology base.

The concept *crime scene* (gerningssted) is not explained in the term list, even though it is emphasized and explained in the introduction of the publication. In our view, this fact may be attributed to the lack of a systematic approach. In this case, the last part of the text includes a text fragment that may be re-used for a definition, see underlined text. Moreover, from the introduction, it appears that the efforts in this area are conducted by the police (Beredskabsstyrelsen, 2018: 7).

The last coordinate concept is *area of operation* (operationsområde). The explanation of this concept also comprises the term *area* (område). The characteristic *restricted* (afgrænset) is redundant since this characteristic is a differentiating characteristic of the concept *place* (sted) and inherited from this. From the subclause "*where....*" ("hvor ......"), it only appears that an effort conducted by the police takes place or is going to take place. However, in the last part of the explanation, we find the differentiating characteristic indicating that *area of operation* (operationsområde) is set up for especially severe incidents.

In their articles, Elmhadhbi et al. (2020), Gaur et al. (2019), and Sinha & Dutta (2020) also discuss the role of definitions in ontologies. In their literature review in the domain of disaster response, Elmhadhbi et al. (2020) refer to several ontologies. They point out that these ontologies do not cover the knowledge of the various actors involved in the disaster response process. In our study, however, the purpose of the explanations in Beredskabsstyrelsen (2018: 64-70) was a common understanding for all actors within the domain of incident management (Beredskabsstyrelsen, 2018: 7). In their work in the POLARISCO project, Elmhadhbi et al. (2020) establish a domain ontology "with the main goal of making the best possible definitions of stakeholders' technical vocabulary." Moreover, Elmhadhbi et al. (2020) stress that the terms in the ontologies should be defined in a consistent manner in order to enhance communication and increase interoperability of information exchange among various actors. However, in their articles, neither Elmhadhbi et al. (2020) nor Gaur et al. (2019) nor Sinha & Dutta (2020) propose explicit guidelines how to formulate precise and consistent definitions as it seen in terminological literature recommending intensional definitions.

Elmhadhbi et al. (2020), Gaur et al. (2019) and Sinha & Dutta (2020), all focus on IT systems as users of the ontologies and

TABLE 2 Rewriting explanations into intensional definitions

Concept	Notation	Attribute–value pair	Explanation in the term list	Definition proposed by us
location (lokation)	2.3	*PLACES: activity or object (PLACERER: aktivitet eller objekt)*	Not in the term list by Beredskabsstyrelsen (2018)	*place in which something happens or is situated (DANTERMcentret, 2013) (sted hvor noget sker eller er beliggende (DANTERMcentret, 2013))*
response area (indsatsom-råde)	2.3.1	*INCIDENT EFFORTS:total fire and rescue operation (INDSATS: samlet beredskabsmæssig indsats)*	*The total <u>area in which a fire and rescue operation is carried out</u>. Thus, the response area is the working area as well as the area of responsibility of the incident management. The response area is delimited by the outer cordon. See also site of damage. (Det samlede <u>område, hvor en beredskabsmæssig indsats foregår</u>. Indsatsområdet er således indsatsledelsens arbejds- og ansvarsområde. Indsatsområdet afgrænses af den ydre afspærring. Se også skadested.) (Beredskabsstyrelsen, 2018: 66)*	*location in which the total fire and rescue operation takes place (lokation hvor den samlede beredskabsmæssige indsats foregår)*
crime scene (gerningssted)	2.3.2	*INCIDENT EFFORTS: finding relevant clues (INDSATS: politimæssig indsats mhp. at finde konkrete spor)*	*From a <u>police point of view</u>, a crime scene may be involved over and above the three areas mentioned above. Normally, the crime scene is larger than the site of damage, including the entire <u>area in which concrete clues may be identified</u>. (Ud over disse tre områder kan der i <u>politimæssig</u> forstand være tale om et gerningssted. Gerningsstedet vil typisk have en større udstrækning end skadestedet og omfatter hele det <u>område, hvor der er mulighed for at finde konkrete spor</u>.) (Beredskabsstyrelsen, 2018: 7)*	*location in which a police operation is carried out in order to secure specific clues (lokation hvor der foregår en politimæssig indsats for at finde mulige, konkrete spor)*
area of operation (operationsområde)	2.3.3	*INCIDENT EFFORTS: isolated police operation related to special danger (INDSATS: isoleret politimæssig indsats ved særlig fare)*	*A restricted <u>area in which a specific police operation is carried out or is planned to be carried out</u> by specially trained police personnel. An area of operation will be established in the event of an incident the content and/or extent of which poses a particular threat to persons or values. (Et afgrænset <u>område, hvor der foregår eller skal foregå en isoleret politimæssig indsats</u>, som udføres af særligt uddannet politipersonale. Et operationsområde oprettes ved en hændelse, som i indhold og/eller omfang <u>udgør en særlig fare</u> for mennesker eller værdier.) (Beredskabsstyrelsen, 2018: 68)*	*location in which a restricted police operation is carried out in case of acute danger (lokation hvor der foregår en isoleret politimæssig indsats ved særlig fare)*

Underlining marks input to the definitions.

definitions. In our article, we also see citizens in general as target group of our results, see Section 6 Terminological Resources.

Finally, both Elmhadhbi et al. (2020) and Sinha & Dutta (2020: 150) focus on defining upper-level ontologies or high-level concepts in order to align more domain ontologies and enable interoperability between them (Elmhadhbi et al., 2020). Based on former ontology work within the Danish network of FORVIR, we agree with this approach.

6 | TERMINOLOGICAL RESOURCES

The coverage of Danish terminology in international terminology resources is often rather limited. We observed this in the Danish terminology of disaster management recorded in IATE, the EU term bank, (Translation Centre for the Bodies of the European Union, 2020, May), (http://iate.europa.eu/). Searches for the 46 Danish terms resulted in as little as 17 hits. In addition, Danish is included in the two international thesauri EuroVoc, the EU's multilingual thesaurus (Publications Office of the European Union, 2020), (http://eurovoc.europa.eu/), and GEMET, the GEneral Multilingual Environmental Thesaurus (European Environment Agency (EEA) (2019, February), (https://www.eionet.europa.eu/gemet/en/groups/). In EuroVoc none of the 46 Danish terms was registered. In GEMET, only one Danish term from the term list could be found in GEMET. Moreover, searches in the two thesauri resulted in Danish term entries including definitions in English only. However, due to cultural differences, the English definitions shown with the Danish concepts may be misleading.

Ideally, the results of terminology work are stored in in-house terminology bases of enterprises or organizations or even in large national or international term banks such as IATE or the Rikstermbanken, Sweden's national term bank (Språkrådet, 2019, August), (http://www.rikstermbanken.se). The public has free access to the two term banks mentioned. In the event of the establishment of a regional or national Danish term bank, we plan to store our results in this term bank, since the topic of disaster management is of common relevance to the public sector and to citizens in general. Such a term bank may give the public sector and the citizens access to information about key terms in Danish within important domains, for example the tax system, the labour market or disaster management. Since terminology banks comprise definitions, they also support a common understanding of the key terms included and thereby ensure efficient communication.

Moreover, since studies on disaster management terminology have been carried out in Norway and Sweden, a perspective might be to collect, compare and exchange terminological information on disaster management across the Nordic languages together with Nordic colleagues and store the results in a Nordic terminology base.

7 | CONCLUSION

Building ontologies on the basis of identification and formalization of characteristics in the form of feature specifications creates a good foundation for reaching consensus about definitions of concepts, for example in a standardization process. The results of this study represent a first step by means of which we demonstrate that results based on terminological principles form a basis for further systematic concept clarification and ontology building within disaster management terminology. Based on our studies for this article, we also see perspectives in integrating terminological resources and ontologies into disaster management systems, thus giving all users access to structured information with definitions.

As mentioned in *Section 1. Introduction*, we already have access to fully automatic corpus-driven term extraction tools, which also may include access to social media, but the automatic ontology building is still in its early stage of development (Zhang and Khurshid, 2014: 51). However, further development of tools for automatic ontology building may result in increased number of terminological ontologies, which may be used for the elaboration of common definitions, and thereby increase interoperability between various disaster management systems, both nationally and across international boundaries.

Moreover, terminology resources may form the basis of thesauri and classifications of high quality. As mentioned above, the terminology included in DEMA's Danish term list is scantily and insufficiently represented in international thesauri. Therefore, another perspective may be to show to what extent the results of terminological studies may improve thesauri, and specifically, in what ways the ontology and the definitions resulting from this study may be suitable as a basis for a thesaurus covering part of the domain of disaster management.

Further, terminological ontologies including attribute–value pairs may constitute the first step in data modelling and thus in developing IT systems including improved user interfaces for disaster management systems (Madsen & Thomsen, 2015: 250–275). The usefulness of terminological ontologies as a prerequisite for IT development and data modelling is already known from the Danish public sector. Also, the ontologies may serve as building blocks of semantic technologies that may support the mediation of standardized information creation and exchange in disaster risk management. Finally, in a report on language technology conducted by the Danish Language Council on the use of Danish in technologies involving language and Artificial Intelligence, the need of fundamental Danish language resources of a high quality, for example terminology, was pointed out (Dansk Sprognævn 2019: 5).

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APPENDIX 1

The top of the Ontology of Incident Management (Indsatsledelse)