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Interoperability of Early Warning Systems for Disaster Risk Reduction:

A Systematic Literature Review

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Abstract

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List of Acronyms

|  |  |
| --- | --- |
| DM | Disaster Management |
| DRR | Disaster Risk Reduction |
| DSS | Decision Support Systems |
| EWS | Early Warning Systems |
| ICT | Information and Communications Technology |
| SA | Situation Awareness |
| SLR | Systematic Literature Review |

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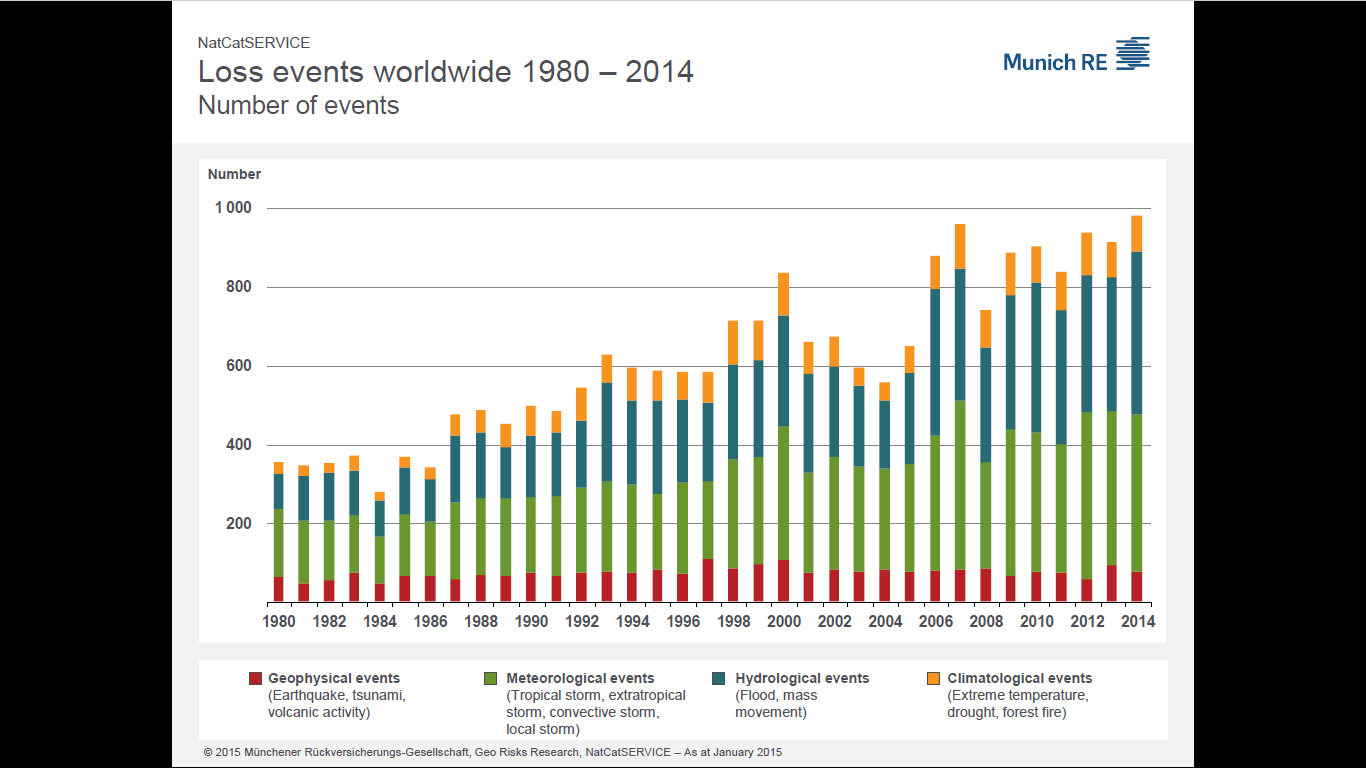
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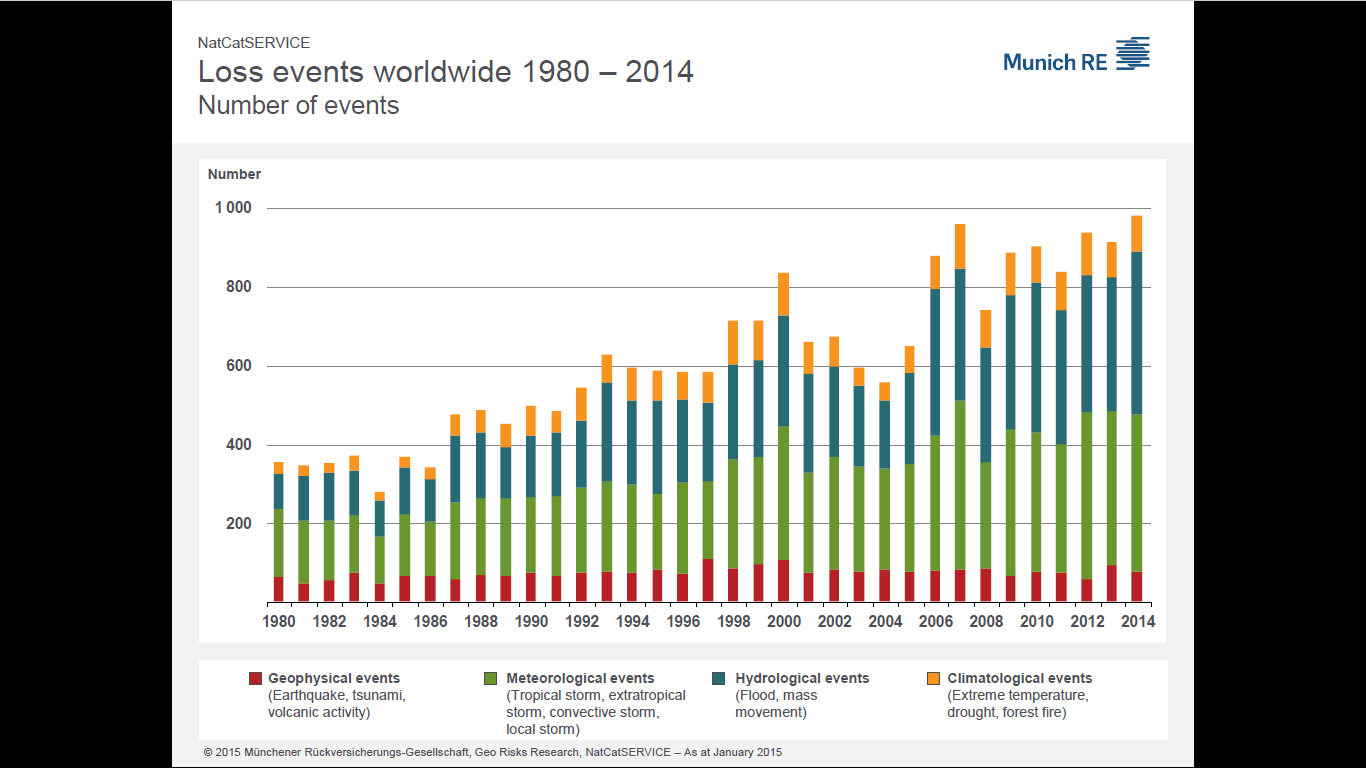
Introduction

## Motivation

Emergency (disaster) management (EM) and disaster risk reduction (DRR) have a high social relevance, where early warning systems (EWSs) play an important role in monitoring events and detecting disaster situations. EWSs have interoperability problems for the realization of the requirements of providing effective collaboration and high situation awareness among the many stakeholders involved, within different domains. In this context, the improvement of semantic interoperability of each party can bring common understanding of the information exchanged. However, a number of semantic interoperability problems arise in each different type of disaster (e.g. epidemics, floods, fire, earthquakes) because of their particular properties. Therefore, the characterization of the specificities of pre-disaster situations must be accurate and well-founded.

According to the United Nation International Strategy for Disaster Reduction (UNISDR), disaster situations have been happening more often in the recent years, having a great societal and economic importance. UNISDR provides statistics (UNISDR, 2013) regarding disaster impacts. From 2000 to 2012 estimating U$ 1.7 trillion spent in recovering from damages of disasters, where more than 2.9 billion people were directly affected, with 1.2 million people killed. According Munich RE NatCatSERVICE, “the most comprehensive natural catastrophe loss database in the world” (NatCatSERVICE, 2015), there is a substantial increase of all types of hazard events leading to disaster situations in the past 30 years, shown in Figure 1.1.





**Figure 2.1:** **Disastrous events over the past 30 years (NatCatSERVICE, 2015).**

The International Disaster Database (EM-DAT) (CRED, 2016) classifies natural disaster events as geophysical, meteorological, hydrological, climatological, biological and extra-terrestrial. The subcategories of each of them are listed in Figure 1.2.

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**Figure 2.2:** **Disastrous event types in EM-DAT.**

According to the official terminology of the international strategy for disaster reduction (ISDR), conducted by the UNISDR, a **disaster** is *“a situation where serious disruption of the functioning of a community or a society occurs, involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources”* (Othman et al., 2014). **Disaster management** (DM), also referred as emergency management or crisis management, addresses an urgent social need with the goal of reducing vulnerability to hazards and coping with disasters. Often in the literature, DM is classified as a process of four phases (Coppola, 2015), illustrated in Figure 1.3.

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**Figure 2.3:** **The disaster management cycle phases.**

1. Mitigation/prevention: preventing, reducing or eliminating human hazard from potential disastrous events. This can be performed through risk assessment and resources planning, including the development of measures to address initial impact.
2. Preparedness: preparing resources for a disastrous event that is about to occur, somehow already detected.
3. Response: responding to a disastrous event, including rescue, relief and salvage, including immediate damage assessment.
4. Recovery: returning the affected area and victims’ lives back to normality by performing detailed damage assessments, as well as restoration, re-habitation and repair.

Table 1.1 gives some examples of these phases for global scale disease epidemics surveillance.

Table 1.1: Disease surveillance by disaster management phases

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| Mitigation/ Prevention | World Health Organization (WHO) mitigates infectious disease outbreaks worldwide, such as the seasonal Influenza[[1]](#footnote-1), by monitoring vaccination schedules and proposing vaccination programs, i.e. a preventive action to avoid or lower the risks of Influenza epidemics. |
| Preparedness | Both (American) Center for Disease Control and Prevention (CDC) [[2]](#footnote-2) and European Centre for Disease Prevention and Control (ECDC) [[3]](#footnote-3) provide preparedness plans for Ebola outbreaks. For example, since Ebola can spread easily and quickly, proper personal protective equipment should be used to protect medics exposed in possible contagion situations. |
| Response | ECDC ensures rapid mobilization of outbreak assistance teams, sufficient diagnosis capacity, proper guidelines and standard operating procedures to investigate the spread. ECDC also supports capacity building in field missions. |
| Recovery | The American Red Cross provides recovery guides for various types of disasters, to assure safe conditions, as well as emotional and financial recover after a disaster happen[[4]](#footnote-4). |

In practice, risk reduction and planning are permanent activities, not triggered by a particular event, while responding and recovering (repairing) are activities that can be triggered by a particular event. Therefore, those four phases are intermixed and are performed to some level before, during, and after disasters. Sometimes the response actions can begin even before the disaster actually happens, triggered by the almost certain expectation that disastrous events will happen.

The modern and holistic paradigm of DM is called disaster risk reduction (DRR), which involves every part of society, including government, public and private organizations. DRR is the “concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and early warning for adverse events are all examples of disaster risk reduction.” (UNISDR, 2016)

The main stakeholder in international DRR is UNISDR, which plays the role of focal point in United Nations (UN) system by coordinating regional organizations and activities in socio-economic and humanitarian fields. UNISDR defines the relation between DRR and DM such as DRR “includes disciplines like disaster management, disaster mitigation and disaster preparedness, but DRR is also part of sustainable development.” (UNISDR, 2016)

Besides UNISDR, stakeholders involved in disaster situations are numerous: the community, local and national governments (e.g. operation centres and military), regional institutions (e.g. hospitals, police and firefighter department, civil defence), international bodies (e.g. UN agencies), and nongovernmental (NGO) organizations (e.g. Red Cross). In epidemic situations, UNISDR is supported by the WHO in setting and implementing norms, standards and technical assistance. WHO is the international lead agency for large scale disease surveillance, working together with regional and national government organizations (as CDC and ECDC). Statistics provided by WHO rely on different sources of data: hand-written medical record and ICT-based, call record (tele-health), Electronic Patient Record (EPR) (Electronic Health Record (EHR)) patient tracking systems and Enterprise Resource Planning (ERP) systems within health facilities.

In this context, Early warning systems (EWS) play an important role in supporting DM, being a major element for DRR by providing capabilities such as: detection, monitoring and forecasting hazard events; risk analysis; warnings dissemination; and execution of emergency plans to prepare and respond. In general, an EWS can be classified as an emergency management system (EMS), supporting emergency agencies, such as UNISDR, in their decision making processes, i.e. can also be classified as a decision support system (DSS). An EWS is defined as a “chain of information communication systems comprising sensor, detection, decision, and broker, in the given order, working in conjunction, forecasting and signalling disturbances adversely affecting the stability of the physical world; and giving sufficient time for the response system to prepare resources and response actions for minimizing the impact on the stability of the physical world” (Waidyanatha, 2010).

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**Figure 2.4:** **Conceptual framework of an EWS as a process of five activities (Waidyanatha, 2010).**

EWS support emergency agencies by increasing their situation awareness about disaster risks. The common conceptual architecture of an integrated EWS is illustrated in Figure 1.4. It resembles to the framework of the Endsley’s Situation Awareness (SA) Theory (Wickens, 2008), a theory well-stablished in the human factors community. EWS conceptual architecture is structured as a process of five steps: sensor, detection, decision, broker and response. The framework of SA theory also considers five activities, having the SA concept framed in three levels: perception, comprehension and projection of future status, illustrated in Figure 1.5.

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**Figure 2.5:** **The model of Endesley[s SA theory in dynamic decision making (Endsley, 1995).**

Notice that there is a direct relation between a component of an EWS and an activity of the SA theory, described as below:

1. Sensor: refers to the first level of SA, i.e. the perception of elements from the current context;
2. Detection: refers to the second level of SA, i.e. the comprehension of these elements and their relations as a whole;
3. Decision: refers to the third level of SA, i.e. the projection of the wanted future status. Moreover, it covers the decision component of the SA theory by performing the decision selection;
4. Broker: refers to decision and performance of actions by mediating between the decision and the response components, where knowledge is shared according to message formats; and
5. Response: refers to the responsible for performing the actions in the field (e.g. evacuation or isolation of a local).

Usually the requirements of a response system guide the entire EWS design. The components of a EWS must exchange data and be well integrated to provide accurate and timely information for decision making through the response system(s). A challenge in EWS components integration is to enable the exchange of information instead of solely the exchange of data. This challenge must consider that a disaster situation is, by nature, complex and dynamic, involving interactions among a number of parties (e.g. emergency agencies, first responders and victims). Hazardous event types lead to disaster situation types, which are characterised by the participants in the events and how they are affected. This complexity brings a number of interoperability challenges. Interoperability is crucial in EWS because it leverages on crowdsourcing thus dealing with information heterogeneity and it is mandatory to avoid misunderstandings when communicating about delicate issues (Casado et al., 2015). Therefore, interoperability plays a determinant role in this context.

According to the General Electrics, the interoperability of systems in healthcare ecosystems could help saving U$ 30 billion per year (GE, 2015). Interoperability is “the ability of two or more systems or components to exchange information and to use the information that has been exchanged” (IEEE, 1990). A broader definition considers human, social, political, and organizational factors that impact all components of an integrated system. Several interoperability classifications exist (Rezaei et al., 2014), and at the application level there are at least the following interoperability aspects to consider:

1. Coding: the binary encoding of the messages/streams that carry data (technological interoperability).
2. Formatting: the packaging of data in a message (syntactic interoperability).
3. Interpretation: the assignment of meaning to the data (semantic interoperability).
4. Dialogue: the process synchronization for the exchange of messages (process interoperability).

Coding and formatting are covered by existing standards, which are defined by international standards consortiums, such as OASIS (OASIS, 2016), the Object Management Group (OMG) (OMG, 2016), the World Wide Web Consortium (W3C) (W3C, 2016) and the Health Level 7 (HL7) (HL7, 2016). These standards enable ICT-based systems to communicate to each other, through common data formats and communication protocols, towards technological and syntactic interoperability. However, interpretation is only partially covered by those standards. Common data standardization is not enough to guarantee that the systems, and more importantly, their (direct or indirect) users, share messages with same meaning. For example, consider a patient tracking system that exchange messages between an Electronic Health Record (EHR) system and an Enterprise Resources Planning (ERP) system of a hospital, which provide services with the message structure of OASIS Emergency Data Exchange Language (EDXL). The standard for tracking patients, coined EDXL-TEP, provides the property “vehicle kind” from the “transport type” entity within the reference model. If the first system generates a message with the value “car” meaning an “ambulance” and the other two systems follows a different definition for the term “car”, e.g. a personal car, then they won’t share the same semantics. Because of this, the decision making can be affected, leading to erroneous procedures. In this example, the hospital is waiting for the patient in an ambulance and, therefore, expects that the first medical procedures are already taken. This is an example of a semantic interoperability problem.

Semantic interoperability refers to the study of meanings. It is the ability to automatically interpret shared data meaningfully and accurately according to agreed-upon semantics, i.e. a common information exchange reference model that produces useful results for end users of the involved systems. It focuses in terminology and deals with human interpretation by exchanging data in an unambiguously way, ensuring that the understanding of the information is the same for senders and receivers. “Semantic interoperability ensures that these exchanges make sense – that the requester and the provider have a common understanding of the “meanings” of the requested services and data” (Heiler, 1995).

According to the formal specification of the Object Management Group (OMG) about information exchange packaging policy vocabulary (IEPPV) [Ref.], to achieve semantic interoperability, the senders and receivers must:

1. Specify structure and syntax of the information exchange by integrating or extending existing standards. E.g. EDXL, National Information Exchange Model(NIEM), HL7.
2. Specify the rules for information assembly and processing in an unambiguous way. Such rules should contain patterns for the aggregation of data, conversion transformations to sharing agreement standards and tagging message elements for operational needs (e.g. privacy, legal issues, and quality of service). Furthermore, these rules include parsing of messages into their constituent information and data elements, validation of sharing agreement requirements and marshaling (assignment and transfer) of data to the appropriate data store.
3. Capture and hold the rules governing the operation of transactional interfaces, enabling certification and accreditation.

Usually, items 2 and 3 are aspects of the application lifecycle not well serviced by traditional development methods and technologies, because the translation of policies and constraints to executable rules (encoded software) is typically based on textual requirements.

## The need for a systematic literature review

In this section we describe the “(…) requirement of researchers to summarize all existing information about some phenomenon in a thorough and unbiased manner” (Hristidis et al., 2010). The phenomenon, i.e. the problem context to be investigated is:

**Interoperability of EWS for DRR**

This effort can be justified by the recent international agenda for DRR from 2015 to 2030, called the Sendai framework (UNISDR, 2015), which replaces the Hyogo framework (2005-2015). The Sendai framework definition was supported by UNISDR and agreed by the world’s main emergency agencies. Sendai presents the requirement of an integrated global warning and response system for epidemics. In particular, it states the need of improvements of the Global Outbreak Alert and Response Network (GOARN) platform[[5]](#footnote-5) through the integration of EWS. This is because Future disease outbreaks may spread faster and stronger than recent epidemics, causing more social and economic impacts (Gates, 2015). Examples of EWS under GOARN umbrella are the Global Public Health Intelligence Network (GPHIN), the HealthMap project and the EpiSpider system (Bello-Orgaz et al., 2014).

Sendai also describes the requirement to “substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information”, i.e. to improve multi-hazard EWS (MHEWS) through the construction and integration of existing and new EWS. The international network for MHEWS (IN-MHEWS), a multi‐stakeholder partnership to facilitate the sharing of expertise and best practice towards Sendai goal, calls for strengthened EWS at all levels by dealing with interoperability issues:

“A key challenge has been in reaching the (…) population with timely, meaningful, and actionable warning information. Several gaps persist due to weak coordination among the actors and agencies concerned. (…) This situation, together with the increasing globalisation of risk, calls for strengthened EWS at all levels. It also calls for an integrated and holistic approach to early warnings for multiple hazards and risks tailored to user needs across sectors. In this regard, international and regional collaboration as well as multi‐stakeholder partnership at all levels is critically necessary, given the transboundary nature of most natural hazards.” (WHO et al., 2015)

Notice that the Sendai requirements for coordination and collaboration through a holistic approach impose efforts in all interoperability aspects, especially the semantic interoperability for exchanging messages among EWS components without losing semantics. Therefore, to achieve the Sendai goal of enhancing MHEWS, through the development of science-based methodologies and tools, it is necessary to improve semantic interoperability of EWS. Moreover, IN-MHEWS enforces the need of inventorying EWS implemented and operated worldwide. It is expected that this requirement will be realized by this systematic literature review.

Numerous research efforts towards Sendai goals are being financed by funding agencies and research & development programs, such as recent H2020 calls in societal challenges for secure societies[[6]](#footnote-6). Related to interoperability, there is a number of past opportunities, as in the context of e-Health, radio communication and the Internet of Things (IoT)[[7]](#footnote-7). The call for disaster resilience in 2015 (H2020-DRS-2015), composed by 22 sub-topics, where DRS-18-2015 and DRS-19-2014 regards interoperability, had a budget of more than €80 million (REA, 2015), emphasizing the need to support UNISDR platforms. Some H2020 open and forthcoming topics where the scope of this work fit are listed below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Level\*** | **Budget** | **Deadline** |
| [SEC-02-DRS-2016](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2319-sec-02-drs-2016.html): Situational awareness systems to support civil protection preparation and operational decision making | 8 | € 1.5mi | August 2016 |
| [SEC-20-BES-2016](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2322-sec-20-bes-2016.html): Border Security: autonomous systems and control systems | 7 | € 8mi | August 2016 |
| [SEC-19-BES-2016](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2321-sec-19-bes-2016.html): Data fusion for maritime security applications | 6 | € 8mi | August 2016 |
| [SEC-14-BES–2016](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2323-sec-14-bes-2016.html): Towards reducing the cost of technologies in land border security applications | 5 | € 5mi | August 2016 |
| [SEC-04-DRS-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2326-sec-04-drs-2017.html): Broadband communication systems | 3 | € 10mi | August 2017 |
| [SEC-13–BES–2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2327-sec-13-bes-2017.html): Next generation of information systems to support EU external policies | 9 | € 10mi | August 2017 |
| [EE-12-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/4089-ee-12-2017.html): Integration of Demand Response in Energy Management Systems while ensuring interoperability through Public Private Partnership (EeB PPP) | 7 | € 8mi | January 2017 |
| [SC1-PM-19-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/3063-sc1-pm-19-2017.html): PPI for uptake of standards for the exchange of digitalised healthcare records | 10 | € 8.2mi | March 2017 |
| [EUB-02-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2080-eub-02-2017.html): IoT Pilots | 5 | € 4.5mi | March 2017 |
| [EINFRA-12-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2121-einfra-12-2017.html): Data and Distributed Computing e-infrastructures for Open Science | 7 | € 40mi | March 2017 |
| [IoT-03-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2221-iot-03-2017.html): R&I on IoT integration and platforms | 8 | € 35mi | April 2017 |
| [SMEInst-13-2016-2017](http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/6116-smeinst-13-2016-2017.html): Engaging SMEs in security research and development | 8 | € 31mi | November 2017 (last) |

\* Level refers to an estimated degree of commonality of this work with the topic (1 to 10), based on the description of the topic’s expected impact.

In the context of H2020 funding opportunities, the Small and Medium-sized Enterprises (SME) instrument[[8]](#footnote-8) will provide € 3bi for SMEs that are EU-based in the period of 2014-2020 to help them grow in the topics under the umbrella of the societal challenges section[[9]](#footnote-9).

## Research methodology, goal and initial questions

The research methodology adopted in this study is the systematic literature review (SLR) for software engineering (SE) described in (KitchenhamCharters, 2007) supported by the Design Science Methodology (DSM) (Wieringa, 2014). A SLR was chosen to respond those questions by finding “as many primary studies relating to the research questions as possible using an unbiased search strategy” (KitchenhamCharters, 2007).

The goal of this work is to investigate the current problems and improvement opportunities, i.e. perform problem investigation (in DSM terminology), in the context of interoperability of EWS for DRR. The top-level and initial knowledge questions we aim on responding are:

1. What disaster management terminology is used in the literature? What are the definitions of key concepts, such as types of disasters, disaster management (DM), disaster risk reduction (DRR), situation awareness (SA), early warning systems (EWS) and multi-hazard EWS (MHEWS).
2. What EWS are used in DRR?
   1. What are their functions?
   2. What are the common architectures?
   3. What are the stakeholders involved?
3. What interoperability problems in EWS are reported in the literature?
   1. What are their possible causes or mechanisms that produce the problems?
   2. What are the classifications of interoperability?
4. What standards are used for DRR?

These questions will be translated to the initial queries to be used over the data sources for the initial data synthesis, presented in chapter 2. The answers for these questions will guide the formulation of the research questions to be answered in this SLR, starting from a design problem and the related knowledge questions.

## Structure

The structure of this report follows the SLR process and is organized as:

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**Figure 2.5:** **Structure of this report based on SLR process phases.**

* Chapter 2 presents the planning phase of the SLR in terms of guidelines, detailing the stakeholder goals, including the review’s objectives, and defining the review protocol, including the sources to be used, the search strategy, the inclusion and exclusion criteria, and the initial data analysis.
* Chapter 3 presents the conducting phase, at first by providing the description of the initial studies collection and, then, the synthesis of the data extracted.
* Chapter 4 presents the final report of the SLR with the summary of the literature and the open issues to be addressed by research efforts.
* Conclusion presents the final remarks about the problem analysis.
* Appendix and attachments.

# Planning

Here we describe the review protocol as guidelines for the conduction of the SLR process. The goals of the main stakeholders involved in this research are detailed in this section. Moreover, it is described in this section the sources searched to identify the studies, the strategy and search strings, inclusion and exclusion criteria, quality assessment and data extraction procedures. The initial data synthesis and the differences to other existing reviews are presented, ensured by a checklist. At last, the review protocol presents the basic definitions to be used in this work, the revised research questions and search strategy.

## Systematic review guidelines

In this section we present the guidelines of the SLR: reviewer’s and stakeholders’ goals, used sources, criteria for inclusion and exclusion and initial data analysis. This gives the necessary input for the review protocol, presented afterwards.

### Reviewer’s objectives

Our goal is to develop a comprehensive and non-biased synthesis of existing work about interoperability of EWS for disaster risk reduction (DRR), identifying problems and improvement possibilities to be addressed by a PhD thesis. This goal is aligned to the goals of the main stakeholder (the sponsor), listed in section 2.1.1.

Our knowledge goal is to describe and explain the phenomena of DRR through the improvement of interoperability of EWS. Therefore, our prediction goal is to better forecast and reduce disaster risks. From the research goals discussed, according the DSM template for design problem, the top-level design goal can be defined as:

* *Improve* interoperability among EWS
* *by* designing an ontology-driven situation-aware framework
* *that* provides modeling for the detection of disasters and planned actions
* *in order* to reduce disaster risks

To achieve this goal, it is expected to define a conceptual framework for EWS interoperability in DRR and research the solutions that already exist to interoperability problems, which is done in this literature review.

### Stakeholders and their goals

The first stakeholder in the context of this SLR is the sponsor of this project, the Brazilian government agency CAPES, which pays the scholarship for this PhD research. In general, CAPES main goal for a PhD scholarship is to enable the training of human resources in a high level education. According to the description of the research project proposal accepted by CAPES, the main goal defined as:

* The creation of an approach that provides context-aware mechanisms to support emergency management through semantic enrichment of situation representations by conceptual models formalized with foundational ontologies.

Specific goals were described as:

* A characterization approach to represent foreseen and unforeseen emergency situations.
* An approach for emergency management based on context-aware platforms, considering situation modelling, service-oriented architecture and machine learning.
* An approach for emergency situation specification.
* The implementation of experiments and proofs-of-concept of the approach.
* The implementation of a prototype and its usage in an example scenario.

Besides the explicit goals listed above, this research can also be classified as exploratory because the “sponsor may still hope that useful results will emerge, but whether this will happen is very uncertain.” (Wieringa, 2014).

Regarding the DRR field, there is a vast list of involved stakeholders, such as the community, national (e.g. operation centers and military) and regional institutions (e.g. health units, police and firefighter departments, civil defense), international bodies (e.g. UN agencies), research organizations (e.g. universities), and nongovernmental (NGO) organizations (e.g. Greenpeace). In the context of EWS for epidemics (disease outbreaks) surveillance, the main stakeholders and their objectives are listed below:

Table 1.2: International bodies

|  |  |  |
| --- | --- | --- |
| **Acronym** | **Name** | **Goal** |
| [UNISDR](https://www.unisdr.org/) | UN Office for Disaster Risk Reduction | “to serve as the focal point in the United Nations system for the coordination of disaster reduction and to ensure synergies among the disaster reduction activities of the United Nations system and regional organizations and activities in socio-economic and humanitarian fields” (…) “facilitate the implementation of the International Strategy for Disaster Reduction (ISDR)” |
| [WHO](http://www.who.int/) | World Health Organisation | “Our primary role is to direct and coordinate international health within the United Nations’ system.” |
| [ECDC](http://ecdc.europa.eu/) | European Centre for Disease Prevention & Control | “EU agency with aim to strengthen Europe's defences against infectious diseases. (…) ECDC's mission is to identify, assess and communicate current and emerging threats to human health posed by infectious diseases.” (Europe) |
| [CDC](http://www.cdc.gov/) | Centers for Disease Control & Prevention | “CDC works 24/7 to protect America from health, safety and security threats, both foreign and in the U.S. (…) CDC fights disease and supports communities and citizens to do the same. (…) As the nation’s health protection agency, CDC saves lives and protects people from health threats. (…) CDC conducts critical science and provides health information that protects our nation against expensive and dangerous health threats” (America) |

Table 1.3: National institutions

|  |  |  |
| --- | --- | --- |
| **Acronym** | **Name** | **Goal** |
| [RIVM](http://www.rivm.nl/) | Rijksinstituut voor Volksgezondheid en Milieu | “prevent and control outbreaks of infectious diseases. We promote public health and consumer safety, and we help to protect the quality of the environment. RIVM collects and collates knowledge and information from various sources, both national and international. We apply this knowledge ourselves, and we place it at the disposal of policy-makers, researchers, regulatory authorities and the general public. Each year, RIVM produces numerous reports on all aspects of public health, nutrition and diet, health care, disaster management, nature and the environment.” (Netherlands) |

Table 1.4: Research organizations

|  |  |  |
| --- | --- | --- |
| **Acronym** | **Name** | **Goal** |
| [CRED](http://www.cred.be/) | Centre for Research on the Epidemiology of Disasters | “It promotes research, training and technical expertise on humanitarian emergencies, with a special focus on public health and epidemiology. (…) The Centre became a World Health Organization (WHO) Collaborating Centre in 1980.” (EU, Brussels) |
| [NIVEL](http://www.nivel.nl/) | Netherlands institute for health services research | “is the national institute for health services research in the Netherlands. It is an independent organization. Its domain is applied and applicable health services research.” (Netherlands) |
| [ISDS](http://www.syndromic.org/about) | International Society for Disease Surveillance | “nonprofit organization founded in 2005 and dedicated to the improvement of population health by advancing the science and practice of disease surveillance. ISDS’s 400+ membership represents professional and academic subject matter experts in the fields of public health surveillance, clinical practice, health informatics, health policy, and other areas related to national and global health surveillance.” |
| [CSTE](http://www.cste.org/) | Council of State and Territorial Epidemiologists | “an organization of member states and territories representing public health epidemiologists. CSTE works to establish more effective relationships among state and other health agencies. It also provides technical advice and assistance to partner organizations and to federal public health agencies such as the CDC. CSTE members have surveillance and epidemiology expertise in a broad range of areas including occupational health, infectious diseases, environmental health, chronic diseases, injury control, maternal and child health, and more. CSTE supports effective public health surveillance and good epidemiologic practice through training, capacity development, and peer consultation.” (America) |

Besides these research organizations, WHO maintains the relationship with a number of collaborating centers, which can be found in the WHO Collaborating Centres Database & Portal[[10]](#footnote-10), the official information source about organizations collaborating with WHO. It provides a search engine with options for search criteria, such as by country and WHO Outputs. According to WHO program budget 2016-2017[[11]](#footnote-11), there are six categories (types) of outcomes:

* + - 1. Communicable diseases
      2. Non-communicable diseases
      3. Promoting health through the life course
      4. Health systems
      5. Preparedness, surveillance and response
      6. Corporate services / enabling functions

Each category is composed by outcomes and each outcome is composed by outputs. By navigating the search options using “WHO outputs” option, it is possible to select each specific related output. For example, the outcome 4.4 is related to this work: “All countries having well-functioning health information, eHealth, research, ethics and knowledge management systems to support national health priorities”. The output 4.4.1 is described as: “Comprehensive monitoring of the global, regional and country health situation, trends, inequalities and determinants, using global standards, including data collection and analysis to address data gaps and system performance assessment”. A deliverable related to this output is the support to “use of international standards for health information and statistics and methods in order to increase the interoperability of data sharing and systems”. Searching in the database by this output, the result is showed in the table below:

Table 1.5: WHO collaborating centers for output 4.4.1

|  |  |  |  |
| --- | --- | --- | --- |
| **Institution** | **Country** | **Title** | **Responsible** |
| Ministerio de Salud de la Nación (MSAL) | ARGENTINA | WHO Collaborating Centre for the Family of International Classifications | RUIZ LUNA Patricia Lorena |
| University of Manchester | UK | WHO Collaborating Centre for Health Indicators | STEIN Claudia Elisabeth |
| National Health and Family Planning Commission of the People's Republic of China | CHINA | WHO Collaborating Centre for Health Information and Informatics | GAO Jun |
| Institute of Medical Information | CHINA | WHO Collaborating Centre for Health and Biomedical Information | VILLEMIN PARTOW Marie Sarah |
| University of Zagreb | CROATIA | WHO Collaborating Centre for HIV Strategic Information | DONOGHOE Martin Christopher |
| Federal Research Institute for Health Organization and Informatics of Ministry of Health of the Russian Federation (FRIHOI of MoH of the RF) | RUSSIA | WHO Collaborating Centre on Health Statistics and Analysis | RAKOVAC Ivo |
| Australian Institute for Health & Welfare (AIHW) | AUSTRALIA | WHO Collaborating Centre for the Family of International Classification | GAO Jun |

Further in this SLR, we shall describe a more comprehensive analysis of the outcomes and their outputs to frame the WHO partners that are addressing interoperability issues.

Other stakeholders to be considered are the companies that provide ICT solutions for DRR, including EWS, patient tracking and EPR systems. They are considered stakeholders in this SLR because they develop and integrate systems, being directly related to interoperability. The companies listed below were pointed as “major players” by the Gartner Magic Quadrant categories:

* [Magic Quadrant for U.S. Emergency/Mass Notification Services](https://www.gartner.com/doc/2696222/magic-quadrant-emergencymass-notification-services)
* [Magic Quadrant for Managed Security Services](https://www.gartner.com/doc/3180719/magic-quadrant-managed-security-services)

The goal of such a company is, usually, to obtain profit by producing, vending and maintaining ICT solutions to support DRR.

Table 1.6: ICT solutions companies

|  |  |  |
| --- | --- | --- |
| **Company** | **ICT solution** | **Description** |
| IBM | [IBM Emergency Management Center](http://www.ibm.com/smarterplanet/us/en/smarter_cities/solutions/solution/planning_mgt_solutions/R321271K60502K40.html) | “Increase situational awareness: Managing an emergency situation involves many agencies, and it can be difficult for governmental systems and processes to transition from normal to extreme operations. For faster and more coordinated emergency responses, managers need information and insights to adapt to rapidly changing situations. The IBM Emergency Management Center solution offers near-real-time situational awareness to help improve decision-making speed, accuracy and effectiveness.” |
| Intermedix | [Clinical Data Exchange (CDX)](https://www.intermedix.com/solutions/cdx) | “(…) technology-enabled solutions for global health and emergency response. Our solutions support and connect health care providers and emergency preparedness & response personnel.”  “The Clinical Data Exchange application is a state NEMSIS repository for collecting, analyzing and reporting pre-hospital patient care data submitted by EMS agencies. With this solution, agencies, regional EMS officials and state administrators can view and analyze a variety of reports within the Web interface for benchmarking and and identifying quality improvement initiatives.” |
| MIR3 | [Emergency Notification Solution For Crisis Management](http://www.mir3.com/solutions/emergency-notification/) | “Intelligent Notification can instantly launch an emergency notification via Web, email or phone to populations of any size across any geographical area. Reach thousands of people in just minutes by a variety of means, including email, mobile phone, SMS message, TTY, BlackBerry Messenger, pager, landline and more, in multiple languages or by a custom method. It reliably delivers an emergency notification to hundreds of thousands of people all over the world simultaneously.”  “Intelligent Notification solutions for business continuity and disaster recovery, business operations, emergency notification, IT alerting, and CRM notification.” |
| FLIR | [FLIR A320 thermal imager](http://www.flir.com/thermography/americas/us/view/?id=60114) | “Initially developed during the global SARS epidemic and now being used to detect persons potentially having “Swine Flu (H1N1)”. FLIRs unique "Automatic Temperature Compensator" normalizes for variations in ambient temperatures (i.e. room temperature), allowing operators to correctly identify out-of-norm persons as compared to the body temperature of all others in close proximity or an average group body temperature.” |
| Everbridge | [Pandemic Communication Kit](http://go.everbridge.com/PandemicPreparednessBestPracWhitePaper-Corp-Oct2014.html?mkt_tok=3RkMMJWWfF9wsRogsqjMZKXonjHpfsX57OstWa61lMI%2F0ER3fOvrPUfGjI4CRcNjI%2BSLDwEYGJlv6SgFSrDBMbFz0bgLWRU%3D) | “Assess your pandemic readiness and pinpoint communication gaps with Everbridge’s Pandemic readiness self-audit worksheet. Review sample messages that can be delivered in the event of a pandemic in our Message Maps document." |

The international consortiums and communities that create and maintain standards for interoperability also play the role of stakeholders in this work. The table below lists these organizations and the standards they provide in the context of this work.

Table 1.7: Consortiums and communities providers of standards for interoperability

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Related standards** |
| [Object Management Group (OMG)](http://www.omg.org/) | “international, open membership, not-for-profit technology standards consortium (…). OMG standards are driven by vendors, end-users, academic institutions and government agencies. OMG Task Forces develop enterprise integration standards for a wide range of technologies and an even wider range of industries.” | Information Exchange Framework™ (IEF™)  Information Exchange Packaging Policy Vocabulary™ (IEPPV™)[[12]](#footnote-12) |
| [OASIS](https://www.oasis-open.org/org) | “a nonprofit consortium that drives the development, convergence and adoption of open standards for the global information society.(…) produces worldwide standards for security, Internet of Things, cloud computing, energy, content technologies, emergency management, and other areas. OASIS open standards offer the potential to lower cost, stimulate innovation, grow global markets, and protect the right of free choice of technology.” | Emergency Data Exchange Language (EDXL) [[13]](#footnote-13) |
| [HL7](http://www.hl7.org/) | “a not-for-profit, ANSI-accredited standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services. HL7 is supported by more than 1,600 members from over 50 countries, including 500+ corporate members representing healthcare providers, government stakeholders, payers, pharmaceutical companies, vendors/suppliers, and consulting firms.” | Reference Information Model (RIM) [[14]](#footnote-14)  CDA® R2 Implementation Guide: Emergency Medical Services; Patient Care Report [[15]](#footnote-15)  Emergency Care committee [[16]](#footnote-16)  Public Health and Emergency Response committee[[17]](#footnote-17) |
| [Public Health Data Standards Consortium (PHDSC)](http://www.phdsc.org/) | “non-profit membership based organization of federal, state and local health agencies; professional associations; academia; public and private sector organizations; international members; and individuals.  Our goal is to empower the healthcare and public health communities with health information technology standards to improve individual and community health.” | Health Information Technology Standards[[18]](#footnote-18)  NCHS/CMS – ICD-9 CM (diagnostic classification for epidemiological and health management purposes) [[19]](#footnote-19) |
| [National Information Exchange Model (NIEM)](https://www.niem.gov) | “a community-driven, standards-based approach to exchanging information.”  “The NIEM Emergency Management (EM) domain works to improve decision-making by organizations that share information relating to emergency response and emergency management and to increase the ability to prepare for, respond to, and recover from emergency situations.” | Emergency management[[20]](#footnote-20) |
| [National Information Exchange Model (NIEM)](https://www.niem.gov) | “a community-driven, standards-based approach to exchanging information.”  “The NIEM Emergency Management (EM) domain works to improve decision-making by organizations that share information relating to emergency response and emergency management and to increase the ability to prepare for, respond to, and recover from emergency situations.” | Emergency management[[21]](#footnote-21) |
| [W3C](https://www.w3.org/) | “international community where Member organizations, a full-time staff, and the public work together to develop Web standards. (…) The W3C mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web.” | Emergency community[[22]](#footnote-22) |
| [ISO](http://www.iso.org/iso/home.htm) | “International Organization for Standardization. We develop and publish International Standards.”  “ISO/TC 184/SC 5 - Interoperability, integration, and architectures for enterprise systems and automation applications” | ISO/TC 184/SC 5 [[23]](#footnote-23) |
| [Center for Medical Interoperability](http://medicalinteroperability.org/) | “(…) organization led by health systems to change how medical technologies work together. We aim to improve real-time information flow and make technology function seamlessly in the background so we can achieve the best possible outcomes for patients. Our members are committed to compelling change and improving patient safety, care quality and outcomes, and reducing clinician burden and waste.” |  |

### Sources searched to identify primary studies

To start the research, a mapping of the available data sources was made to serve as a source for knowledge context, i.e. scientific theories, design specifications, practical and common sense knowledge. As in DSM, those data sources were classified in four categories: scientific, technical and professional literature, and oral communication. A fifth category was added, the informal, mainly “wiki” sites such as Wikipedia and CIPedia. It was assigned an ID with prefix “DS” for each data source (for internal organization purpose).

#### Scientific literature

The list of scientific databases (digital libraries) used here is presented in table 2.2.

Table 2.8: Digital libraries

|  |  |
| --- | --- |
| **ID** | **Database** |
| **DS01** | [ACM Digital Library](http://dl.acm.org/) |
| **DS02** | [Science Direct](http://www.sciencedirect.com/) |
| **DS03** | [Springer](http://www.springer.com) |
| **DS04** | [Google Scholar](https://scholar.google.com/) |
| **DS05** | [IEEExplore](http://ieeexplore.ieee.org) |
| **DS06** | [Citeseer library](http://citeseerx.ist.psu.edu) |
| **DS07** | [Scopus](http://www.scopus.com/) |
| **DS62** | [Wiley](http://onlinelibrary.wiley.com/) |

Since the scientific literature is essential for this SLR and besides those digital libraries, there was an effort on searching the main related journals, conferences, workshops and books. Refer to the appendix for a full list of them. Anyway, searching through the digital libraries cover almost all journals, conferences, workshops and books listed.

#### Technical literature

The technical literature includes technical specifications from standard companies.

Table 2.9: Technical literature

|  |  |  |
| --- | --- | --- |
| **ID** | **Name** | **Description** |
| **DS63** | [Google Patents](https://patents.google.com/) | “For the millions of ideas that have been submitted to either the United States or European patent offices, Google Patents lets you discover, search, and read them online.” |
| **DS64** | [Object Management Group (OMG) specifications](http://www.omg.org/) | “standards for a wide range of technologies and an even wider range of industries.” |
| **DS65** | [OASIS specifications](https://www.oasis-open.org/) | “standards for the global information society.” |
| **DS66** | [HL7 specifications](http://www.hl7.org/) | “related standards for the exchange, integration, sharing, and retrieval of electronic health information” |
| **DS67** | [PHDSC HIT standards](http://www.phdsc.org/standards/health-information-tech-standards.asp) | “The Health Information Technology Standards module is an informational and educational resource that describes HIT standards, the standardization process, and its organizations and activities.” |
| **DS68** | [National Information Exchange Model (NIEM)](https://www.niem.gov/technical/Pages/The-Model.aspx) | “The NIEM model defines terms, definitions, and relationships for data being exchanged. It's currently available in XSD and Microsoft Excel formats, where XSD is the authoritative representation.” |
| **DS69** | [W3C specifications](https://www.w3.org/) | “Web standards. (…) protocols and guidelines that ensure the long-term growth of the Web.” |
| **DS07** | [CORDIS projects search](http://cordis.europa.eu/projects/home_en.html) | Community Research and Development Information Service (CORDIS) “is the European Commission's primary public repository and portal to disseminate information on all EU-funded research projects and their results in the broadest sense.”.  “The primary information source for EU-funded projects”. |

#### Professional literature

The professional literature includes magazines, articles and bulletins from the main stakeholders and related organizations.

Table 2.10: Professional literature

|  |  |  |
| --- | --- | --- |
| **ID** | **Name** | **Description** |
| **DS70** | [International Association of Emergency Managers (IAEM)](http://www.iaem.com/) | “(…) has more than 9,000 members worldwide, is the preeminent international non-profit organization of emergency management professionals. IAEM is dedicated to promoting the "Principles of Emergency Management" and representing professionals whose goals are saving lives and protecting property and the environment during emergencies and disasters. (…) The mission of IAEM is to serve its members by providing information, networking and professional opportunities, and to advance the emergency management profession.” |

#### Oral communication

Oral communication includes presentations and conversations in conferences.

Table 2.11: Oral communication

|  |  |  |
| --- | --- | --- |
| **ID** | **Name** | **Description** |
| **DS71** | [ISCRAM 2015 conference](http://iscram2015.uia.no/) | Notes made by the author. |
| **DS72** | [ISCRAM 2016 conference](http://www.iscram2016.nce.ufrj.br/) | Notes made by the author. |

#### Informal

Informal includes informal knowledge, as “wikis” and news publications.

Table 2.12: Informal knowledge

|  |  |
| --- | --- |
| **ID** | **Name** |
| **DS48** | [Wikipedia](https://www.wikipedia.org/) |
| **DS73** | [CIpedia](https://publicwiki-01.fraunhofer.de/CIPedia/index.php/CIPedia%C2%A9_Main_Page) |
| **DS74** | [Wikiversity](https://en.wikiversity.org/wiki/Wikiversity:Main_Page) |
| **DS54** | Google |
| **DS47** | Media press: news publications |
| **DS75** | Disaster resource GUIDE ([www.disaster-resource.com](http://www.disaster-resource.com)) |

A particularity in DS47 (media press) is the use of Google Alerts for daily news related to epidemics.

### Search strategy: inclusion and exclusion criteria

We adopted a search strategy to, at first, respond the initial knowledge questions (section 1.3) towards an overview of DM, DRR, SA, interoperability and EWS. The idea is to have a quantitative analysis of the existing work by following the inclusion and exclusion criteria presented in this section, to summarize the answers of the initial knowledge questions and to identify the most relevant existing reviews in the context of this work. After that, we aim on revise the protocol, starting with the revision and detail of the initial design problem (stated in section 2.1.1) and formulate the new (and more specific) knowledge questions (in section 2.2) to be answered by this SLR.

The initial inclusion criteria for this SLR are the combination of search strings and synonymous terms with Boolean operators (OR, AND, NOT). The general inclusion and exclusion criteria are described in the tables below.

Table 2.13: General inclusion criteria

|  |  |
| --- | --- |
| IC01 | Include only works published in the data sources listed. |
| IC02 | If two or more works describe the same approach, the latest or more comprehensive one is included. |
| IC03 | Include only works related to at least one of the concepts: DM, DRR, SA, interoperability and EWS. |
| IC04 | Include surveys (reviews) and works related to interoperability and/or address integration issues. |
| IC05 | Include only works written in English. |
| IC06 | Include all works published in 2016. |
| IC07 | If the result is a part of the work which does not present a summary of the work (e.g. acknowledgments, epilogue, dedication, index, etc.) then check the “whole” work (e.g. book) and include it whether it satisfies the other inclusion criteria. |

Table 2.14: General exclusion criteria

|  |  |
| --- | --- |
| EC01 | Exclude any databases that cannot be queried. |
| EC02 | If the same work (project or approach) is presented in another work, then exclude the oldest or the less comprehensive (see IC02). |
| EC03 | Exclude works from conferences published before 2005. |
| EC04 | Exclude works from workshops published before 2010. |
| EC05 | Exclude works where the main theme does not involve computer science. |
| EC06 | Exclude works which have to be purchased (even with UT network access). |
| EC07 | Exclude works published before 2003 if the work is not a foundational theory. |

The importance (priority) is estimated based on weights, considering the publication date (most recent work has higher priority) and the source which the work was published. For example, a book chapter published in 2015 that presents a survey has weight 16. This is a measurement of importance, considered when prioritizing the reading of the works.

Table 2.15: Importance (priority) of work by publication date and source

|  |  |  |
| --- | --- | --- |
| **Type** | **Value** | **Weight** |
| Source | Journal | 10 |
| Source | Book chapter | 8 |
| Source | Magazine | 7 |
| Source | Conference proceeding | 6 |
| Source | Other | 2 |
| Publication date | 2016 | 6 |
| Publication date | 2015 | 5 |
| Publication date | 2014 | 3 |
| Publication date | 2010-2013 | 2 |
| Publication type | Full-paper | 8 |
| Publication type | Short-paper | 4 |
| Publication type | Survey | 2 |
| Publication type | Position | 2 |

A search strategy in “waves” (rounds) was adopted, where each round has a list of search strings to be performed in all digital libraries. The method follows the steps below for each round:

1. Each query from the search strings is performed in each digital library;
2. The total number of results is annotated;
3. In the resulted list for each query, it is checked whether each item fits in the inclusion criteria. If so, it is marked to be included. However, if the item fits in the exclusion criteria, then it is marked as excluded;
4. The number of works to be checked depends on the round;
5. The weight of each work marked to be included is calculated. The list is ordered by this weight (descending);
6. Each work is mapped to the data source(s) where it was found;
7. An analysis about the number of results is made for each round (quantitative);
8. The prioritized list of works is presented (section ) with a high-level summary derived from the title, abstract, introduction and conclusion;
9. The data synthesis about the works as a whole (their relations) is presented and the differences between existing reviews and this SLR is described.

Obs.1: Most relevant works refer to the order by (“sort by”) functionality presented in all digital libraries advanced search.

Obs.2: When searching Springer library, the results must consider only the content types of “chapter”, “article” in the disciplines of “computer science” and “engineering”.

The output of this initial search strategy will be used to review this protocol and to select basic definitions to be used in the remaining of this SLR. Bellow we present each round with the sets of search strings. It was assigned an ID for each search string with prefix “SS”, which can be used to compose other search strings. The terms within the search strings are derived from the knowledge questions with the purpose of answering them.

#### Round 1. Most relevant works in emergency management

Table 2.16: Search strings of the first round

|  |  |  |
| --- | --- | --- |
| **ID** | **Search string** | **Knowledge questions** |
| SS01 | “emergency management” | KQ.01 |
| SS02 | “disaster risk reduction” | KQ.01, KQ.02 |
| SS03 | “situation awareness” | KQ.01 |
| SS04 | “interoperability” | KQ.03 |
| SS05 | SS01 AND SS02 |  |
| SS06 | SS05 AND SS03 |  |
| SS07 | SS06 AND SS04 |  |

Table 2.17: Search strings of the first round (synonymous terms)

|  |  |  |  |
| --- | --- | --- | --- |
| **Original term** | | **Replace to** | |
| SS01 | “emergency management” | SS08 | “disaster management” |
| SS01 | “emergency management” | SS09 | “crisis management” |

Table 2.18: Search strings of the first round with synonymous replaced

|  |  |
| --- | --- |
| **ID** | **Search string** |
| SS62 | SS08 AND SS02 |
| SS63 | SS62 AND SS03 |
| SS64 | SS63 AND SS04 |
| SS65 | SS09 AND SS02 |
| SS66 | SS65 AND SS03 |
| SS67 | SS66 AND SS04 |

The expected outputs of SS01 to SS04 are the most relevant works in each of these subjects. The number of works to be checked in this round is the first 20 results (by relevance) for each pair of search string/digital library. Besides helping to answer the knowledge questions, the results will show the level of importance of these subjects by the number of publications. The term EWS is not included in this first round because it is used on the round related to existing solutions (treatments) in the field of DM and DRR.

Usually, the terms “emergency management” (SS01) is synonymous to “disaster management” (SS08) and “crisis management” (SS09), although the concepts of these terms without the “management” term (i.e. “emergency”, “disaster”, “crisis” and “catastrophes”) have different meanings: “There is general acceptance amongst the research community that emergencies are different from disasters, and disasters are different from catastrophes” (Way, 2013). Here we will use the term DM to refer to the concept.

Since UNISDR considers that “disaster risk reduction includes disciplines like disaster management” (UNISDR, 2016) or it is considered as “the evolution of disaster management thinking”[[24]](#footnote-24), we will focus our search in DRR term. This is the reason that SS05-SS07 and SS62 -SS67 consider this term, as well used in later search strings.

Besides the calculation of the weights of the works, additional points are added for the results from search strings that combine the terms more relevant to this SLR (SS05-SS07 and SS62-SS67), according to this table:

Table 2.19: Additional weights for search strings containing the most relevant terms for this SLR

|  |  |
| --- | --- |
| **Search string** | **Weight** |
| SS05 | 6 |
| SS06 | 8 |
| SS07 | 10 |
| SS62 | 6 |
| SS63 | 8 |
| SS64 | 10 |
| SS65 | 6 |
| SS66 | 8 |
| SS67 | 10 |

#### Round 2. Most relevant works about interoperability in emergency context

Table 2.20: Search strings of the second round

|  |  |
| --- | --- |
| SS10 | SS04 AND SS01 |
| SS11 | SS04 AND SS02 |
| SS12 | SS04 AND SS03 |
| SS13 | SS04 AND SS08 |
| SS14 | SS04 AND SS09 |

Table 2.21: Search strings of the second round replacing “interoperability” for “semantic interoperability”

|  |  |  |  |
| --- | --- | --- | --- |
| **Original term** | | **Replace to** | |
| SS04 | “interoperability” | SS15 | “semantic interoperability” |

Table 2.22: Search strings of the second round for semantic interoperability

|  |  |
| --- | --- |
| SS16 | SS15 AND SS01 |
| SS17 | SS15 AND SS02 |
| SS18 | SS15 AND SS03 |
| SS19 | SS15 AND SS08 |
| SS20 | SS15 AND SS09 |

The expected outputs of this round is a filter of the first round to frame the works related to interoperability. Moreover, since it is expected a large number of results, we constrain the search for semantic interoperability. This way it is possible to measure the percentage of works specifically about semantic interoperability among the works related to interoperability. Besides the calculation of the weights of the works, additional points are added for the results, according to the rules of this table:

|  |  |
| --- | --- |
| **Criteria** | **Weight** |
| If SS15 is mentioned in the title or keywords | 15 |
| If SS01-SS03, SS08, SS09 is mentioned in the title or keywords | 12 |
| If SS04 is mentioned in the title or keywords | 10 |
| If *directly related term* is mentioned in the title or keywords | 8 |

*Terms directly related* to interoperability are listed below:

|  |  |
| --- | --- |
| **ID** | **Directly related term with interoperability** |
|  | Standard / standardization |
|  | Ontology / ontologies / ontological |
|  | Integration / integrated |
|  | Information sharing |
|  | Collaboration / collaborative |
|  | Context information |
|  | Geospatial data |

#### Round 3. Existing treatments for interoperability issues in EWS

Table 2.23: Search strings of the third round

|  |  |  |
| --- | --- | --- |
| **ID** | **Search string** | **Knowledge questions** |
| SS22 | “early warning system” | KQ.02, KQ.03 |
| SS31 | SS10 AND SS22 |  |
| SS32 | SS11 AND SS22 |  |
| SS33 | SS12 AND SS22 |  |
| SS34 | SS13 AND SS22 |  |
| SS35 | SS14 AND SS22 |  |

#### Round 4. Literature reviews about interoperability in EWS

Table 2.24: Search strings of the fourth round

|  |  |  |
| --- | --- | --- |
| **ID** | **Search string** | **Knowledge questions** |
| SS51 | “literature review” | KQ.01, KQ.02, KQ.03 |
| SS52 | SS22 AND SS51 |  |
| SS53 | SS52 AND SS02 |  |
| SS54 | SS52 AND SS04 |  |

#### Round 5. EWS functions and architectures

Table 2.25: Search strings of the fifth round

|  |  |  |
| --- | --- | --- |
| **ID** | **Search string** | **Knowledge questions** |
| SS55 | SS02 AND SS22 | KQ.02 |
| SS56 | SS22 AND (“function” OR “capability” OR “role” OR “mission” OR “goal” OR “requirements”) |  |
| SS57 | SS22 AND (“architecture” OR “framework”) |  |

### Data extraction

The execution of the rounds within the initial search strategy is described in this section. At first a quantitative analysis about the overall results of each round is described. Then, the list of works selected in each round is presented, having the same works found in different libraries and different rounds mapped. At last, each work is summarized by using the table below, based on the engineering cycle of DSM.

|  |  |
| --- | --- |
| **Data source(s):** IDs. | **Year:** publication |
| **Criteria:** inclusion criteria used. | **Weight:** importance |
| **Title:** title of the reference. | |
| **Background, scope, stakeholders and goals:**   * What is the context (social and problem)? * Who are the stakeholders?   + Classify on [normal operators, maintenance and operational support], [functional beneficiaries, interface systems responsible], [financial, political beneficiaries, negative stakeholder, threat agent], [sponsor, purchaser, developer, consultant, supplier].   + Awareness level (not aware, not interested, aware/desire). * What are the goals?   + Business goals (social context goals)?   + DS research goals (instrument, knowledge, prediction, artefact design)?   + Desires and their conflicts (logical, physical or technical)?   + What background knowledge is available? Scientific theories? * How implementation evaluation and problem investigation were performed?   + Research method: survey or observational case study or single-case mechanism or statistical difference-making?   + Prototype implemented and available? * What new knowledge it produces? * What is the scope (class of problem contexts and applicable artefacts)? * What are the requirements?   + What are the contribution arguments?   + Classify in FR and NFR.   + What are the indicators and norms? | |
| **Design problem and knowledge questions:**   * Is the research problem a design problem or a knowledge question? * Design problem reformulated as the template (missing information?). * Classify the knowledge questions as [effect, trade-off, sensitivity] and [descriptive, explanatory] and [open, closed questions]? | |
| **Conceptual framework:**   * Architectural and/or statistical? * Functions? | |
| **Treatment proposed:**   * What is the intended interaction artefact x problem context? | |
| **Treatment validation:**   * Validation model? * Research method (expert opinion, single-case, technical action, statistical) * Scaling up (stable regularities x robust mechanisms)? | |
| **Framing in the engineering cycle:**   * In which part of the cycle are the main contributions? | |

#### Round 1. Most relevant works in emergency management

Quantitative analysis:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Database / Search string** | **DS01** | **DS02** | **DS03** | **DS04** | **DS05** | **DS06** | **DS07** |
| [**ACM Digital Library**](http://dl.acm.org/) | [**Science Direct**](http://www.sciencedirect.com/) | [**Springer**](http://link.springer.com/search?query=%22emergency+management%22) | [**Google Scholar**](https://scholar.google.com/) | [**IEEExplore**](http://ieeexplore.ieee.org/) | [**Citeseer library**](http://citeseerx.ist.psu.edu/) | [**Scopus**](http://www.scopus.com/) |
| **SS01** | [120,850](http://dl.acm.org/results.cfm?within=owners.owner%3DHOSTED&srt=_score&query=%E2%80%9Cemergency+management%E2%80%9D&Go.x=40&Go.y=4) | [9,919](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-938998760&_sort=r&_st=13&view=c&md5=60c53b9eb486d111da33652b017bc891&searchtype=a) | [449](http://link.springer.com/search?facet-discipline=%22Computer+Science%22&facet-discipline=%22Engineering%22&query=%22emergency+management%22) | 288,000 | 2,336 | 20.291 | 32,243 |
| **SS02** | 1 | 1,047 | 3,807 | 24,600 | 24 | 2.377 | 4,495 |
| **SS03** | 424 | 2,180 | 4,925 | 59,200 | 1,501 | 18.318 | 13,117 |
| **SS04** | 2,875 | 19,381 | 41,816 | 721,000 | 11,420 | 137.234 | 71,888 |
| **SS05** | 0 | 276 | 417 | 5,920 | 8 | 616 | 934 |
| **SS06** | 0 | 6 | 6 | 121 | 4 | 39 | 10 |
| **SS07** | 0 | 1 | 2 | 47 | 2 | 27 | 0 |
| **SS62** | 1 | 486 | 900 | 11,100 | 5 | 1292 | 1,627 |
| **SS63** | 0 | 2 | 5 | 118 | 4 | 32 | 7 |
| **SS64** | 0 | 1 | 1 | 50 | 2 | 22 | 0 |
| **SS09** | 91 | 6202 | 10298 | 339000 | 1049 | 13543 | 21317 |
| **SS65** | 0 | 84 | 182 | 2,580 | 17 | 261 | 408 |
| **SS66** | 0 | 5 | 6 | 103 | 3 | 26 | 12 |
| **SS67** | 0 | 1 | 2 | 46 | 2 | 19 | 0 |

Those results show some expected outcomes. First, there is a vast number of works in the context of emergency. The term “emergency management” (SS01) is the most used when comparing to “disaster management” (SS08) and “crisis management” (SS09). For instance, in Science Direct (DS02), SS01 returned 9,919 results, while SS08 returned 4,962 and SS09 returned 6,202.

Second, comparing DM and its synonymous with DRR (SS02), the number of citation occurrences is much less. For example, in Science Direct there were 1,047 results for DRR, more than four times less than DM. This can be explained because the concept of DM has been used more often since the 60’s while DRR is used more often since the 90’s, especially after the creation of UNISDR (1999). An anomaly found is the number of results returned from ACM digital library for DRR: only one (Stevens, 2013). The terms “situation awareness” and “interoperability” have numerous citations, as already expected, especially “interoperability”.

Third, when filtering the results with DRR term, the number of results decreases substantially, as can be seen in SS05-SS07 and SS62-SS67. For example, Science Direct returns 276 results for SS05 (“emergency management” AND “disaster risk reduction”) and only one (C. J. Van Westen, 2013) for SS64 (DM and DRR and SA and “interoperability”).

For each query in each digital library, the first 20 were selected, ordered by relevance (available in all digital libraries), and each result was checked according to the inclusion and exclusion criteria. The weight (priority) is calculated as described in section 2.1.4.

The list of works selected in this first round is presented in the table below:

Table 2.26: Works selected in the first round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference** | **Search strings** | **Data sources** | **Is survey?** | **Weight** |
| (Karma et al., 2015) | SS67 | DS02, DS04 | yes | 35 |
| (Tomaszewski, 2014) | SS64 | DS04 | yes | 33 |
| (Baldini et al., 2014) | SS07, SS64, SS67 | DS05 | yes | 33 |
| (Cees J Van Westen, 2013) | SS07 | DS04 | yes | 32 |
| (Loukas et al., 2013) | SS07 | DS04 | yes | 32 |
| (Steenbruggen et al., 2013) | SS07, SS64, SS67 | DS04 | yes | 32 |
| (Yap, 2011) | SS07, SS64 | DS04 | yes | 32 |
| (Al-Khudhairy, 2010) | SS64, SS67 | DS04 | yes | 32 |
| (WächterUsländer, 2014) | SS07, SS67 | DS03 | yes | 31 |
| (Moreau et al., 2014) | SS67 | DS04 | yes | 31 |
| (Pesaresi et al., 2013) | SS67 | DS05 | yes | 30 |
| (C. J. Van Westen, 2013) | SS07, SS64 | DS02, DS04 | yes | 30 |
| (Walker, 2011) | SS07, SS64 | DS04, DS05 | yes | 30 |
| (Poblet et al., 2014) | SS07, SS64, SS67 | DS03, DS04 | yes | 29 |
| (Baubion, 2013) | SS67 | DS04 | yes | 29 |
| (Owen et al., 2014) | SS07 | DS04 | yes | 27 |
| (Khawaja et al., 2014) | SS67 | DS04 | yes | 27 |
| (Ernstsen, 2014) | SS07, SS64, SS67 | DS04 | yes | 25 |
| (Brooijmans, 2008) | SS64 | DS04 | yes | 22 |
| (Curnin et al., 2014) | SS01 | DS03 | no | 21 |
| (Olteanu et al., 2015) | SS01 | DS01, DS55 |  | 19 |
| (Nicola et al., 2014) | SS01 | DS03 |  | 17 |
| (YatesPaquette, 2011) | SS01 | DS04 |  | 16 |
| (Agostino et al., 2015) | SS01 | DS01, DS58 |  | 15 |
| (PengYu, 2014) | SS01 | DS02 |  | 14 |
| (Saeed et al., 2013) | SS01 | DS03 |  | 14 |
| (Rafael et al., 2013) | SS01 | DS01, DS58 |  | 14 |
| (Yuan, 2012) | SS01 | DS03 |  | 14 |
| (Han et al., 2012) | SS01 | DS03 |  | 14 |
| (Kapucu, 2012) | SS01 | DS02 |  | 14 |
| (WaughStreib, 2006) | SS01 | DS04 |  | 14 |
| (Liu, 2013) | SS01 | DS03 |  | 12 |
| (Raue et al., 2013) | SS01 | DS01, DS57 |  | 12 |
| (Pohl et al., 2012) | SS01 | DS01, DS59 |  | 12 |
| (Mocito et al., 2010) | SS01 | DS01, DS56 |  | 12 |
| (Turcanu et al., 2008) | SS01 | DS03 |  | 12 |
| (CarverTuroff, 2007) | SS01 | DS04 |  | 11 |
| (Marinovic et al., 2011) | SS01 | DS01, DS61 |  | 10 |
| (Su et al., 2010) | SS01 | DS03 |  | 10 |
| (Tarchi et al., 2009) | SS01 | DS01, DS56 |  | 10 |
| (Krupka et al., 2009) | SS01 | DS03 |  | 10 |
| (Qiuyan et al., 2008) | SS01 | DS01, DS60 |  | 10 |

#### Round 2. Most relevant works about interoperability in emergency context

The query generated from the keywords combination was:

DS01: ("interoperability") && ("emergency management" || "disaster risk reduction" || "situation awareness" || "disaster management" || "crisis management")

DS02-DS07, DS62: "interoperability" and ("emergency management" or "disaster risk reduction" or "situation awareness" or "disaster management" or "crisis management")

Obs.1: the syntax of this query is different in each data source.

Obs.2: CiteSeer (DS06) was removed because, during the course of this work, the search engine presented changes, returning a huge number of results for any query. For example, the search for “interoperability” and “disaster” returns 3,954,219 rows. This brings a reliability problem to trust the results. Therefore, we removed CiteSeer (DS06) and we added Wiley (DS62).

Quantitative analysis:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Database / Search string** | **DS01** | **DS02** | **DS03** | **DS04** | **DS05** | **DS07** | **DS62** |
| [**ACM Digital Library**](http://dl.acm.org/) | [**Science Direct**](http://www.sciencedirect.com/) | [**Springer**](http://link.springer.com/search?query=%22emergency+management%22) | [**Google Scholar**](https://scholar.google.com/) | [**IEEExplore**](http://ieeexplore.ieee.org/) | [**Scopus**](http://www.scopus.com/) | [**Wiley**](http://onlinelibrary.wiley.com/) |
| **Round 2** | [22](http://dl.acm.org/results.cfm?query=%28%22interoperability%22%29+%26%26+%28%22emergency+management%22+%7C%7C+%22disaster+risk+reduction%22+%7C%7C+%22situation+awareness%22+%7C%7C+%22disaster+management%22+%7C%7C+%22crisis+management%22%29&Go.x=0&Go.y=0) | [770](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-1012272426&_sort=r&_st=13&view=c&md5=a5eacd686d48c6d448b5c9795b3b38c2&searchtype=a) | [1,697](http://link.springer.com/search?query=%22interoperability%22+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29) | [66](https://scholar.google.nl/scholar?hl=pt-BR&as_sdt=0,5&q=%22interoperability%22+and+(%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situational+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22)) | [2](http://ieeexplore.ieee.org/search/searchresult.jsp?newsearch=true&queryText=.QT.interoperability.QT.%20and%20.LB..QT.emergency%20management.QT.%20or%20.QT.disaster%20risk%20reduction.QT.%20or%20.QT.situation%20awareness.QT.%20or%20.QT.disaster%20management.QT.%20or%20.QT.crisis%20management.QT..RB.) | [362](https://www.scopus.com/results/results.uri?numberOfFields=0&src=s&clickedLink=&edit=&editSaveSearch=&origin=searchbasic&authorTab=&affiliationTab=&advancedTab=&scint=1&menu=search&tablin=&searchterm1=%22interoperability%22+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&field1=TITLE_ABS_KEY&dateType=Publication_Date_Type&yearFrom=Before+1960&yearTo=Present&loadDate=7&documenttype=All&subjects=LFSC&_subjects=on&subjects=HLSC&_subjects=on&subjects=PHSC&_subjects=on&subjects=SOSC&_subjects=on&st1=%22interoperability%22+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&st2=&sot=b&sdt=b&sl=164&s=TITLE-ABS-KEY%28%22interoperability%22+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29%29&sid=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A30&searchId=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A30&txGid=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A3&sort=plf-f&originationType=b&rr=) | [455](http://onlinelibrary.wiley.com/advanced/search/results/reentry?scope=allContent&query=%22interoperability%22+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&inTheLastList=6&queryStringEntered=false&searchRowCriteria%5b0%5d.fieldName=all-fields&searchRowCriteria%5b0%5d.booleanConnector=and&searchRowCriteria%5b1%5d.fieldName=all-fields&searchRowCriteria%5b1%5d.booleanConnector=and&searchRowCriteria%5b2%5d.fieldName=all-fields&searchRowCriteria%5b2%5d.booleanConnector=and&start=1&ordering=relevancy) |

The results show how interoperability has a great importance in emergency context, being targeted by a series of works. The difference of the number of results in each data source follows a similar behavior observed in the first round. However, in this case, Google Scholar (DS04) returned less occurrences than Springer (DS03), ScienceDirect (DS02), Wiley (DS67) and Scopus (DS07), different from the results in the first round. The reason for this discrepancy should be the use of the technical term “interoperability”, which is mostly cited by research in computer science field. The terms used in the first round are more general. Despite this issue, Google Scholar recommended to use the term “situational awareness”, which returned 66 results, covering the 39 results with the term “situation awareness”.

In this round, we checked whether each result fits on the inclusion/exclusion criteria, until the list ends or 10 works are marked to be included. Then, we merged the selected works among the data sources. The list of this second round is presented in the table below:

Table 2.26: Works selected in the second round

|  |  |  |  |
| --- | --- | --- | --- |
| **Reference** | **Data sources** | **Is survey?** | **Weight** |
|  | DS01, | no |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference** | **Search strings** | **Data sources** | **Is survey?** | **Weight** |
| (HenriquesRego, 2008) | SS10-14 | DS01, | no | 6+4+22 |
| (Gustavsson et al., 2008) | SS10-14 | DS01, |  | 6+4+20 |
| (Mattson et al., 2008) | SS10-14 | DS01, |  | 6+4+22 |
| (ShaoMcGraw, 2009) | SS10-14 | DS01, |  | 6+4+22 |
| (Bruzzone et al., 2014) | SS10-14 | DS01, |  | 6+3+4+22 |
| (Bertolli et al., 2010) | SS10-14 | DS01, |  | 6+2+4+20 |
| (Ortega et al., 2010) | SS10-14 | DS01, |  | 6+2+4+10 |
| (Macário et al., 2009) | SS10-14 | DS01, |  | 6+4+15+8 |
| (Truong et al., 2009) | SS10-14 | DS01, |  | 6+4+20 |
| (Maybury, 2012) | SS10-14 | DS01, |  | 6+2+4+10 |
| (Mendonça et al., 2007) | SS10-14 | DS01, |  | 6+4+12 |
| (Rocha et al., 2012) | SS10-14 | DS01, |  | 6+2+4+10 |
| (Atluri et al., 2011) | SS10-14 | DS01, |  | 6+2+4+22 |
| (Iapichino et al., 2009) | SS10-14 | DS01, |  | 6+4+12 |
| (Panangadan et al., 2012) | SS10-14 | DS01, |  | 6+2+4+12 |
| (Kewley et al., 2015) | SS10-14 | DS01, |  | 6+5+4 |
| (Hurvitz, 2008) | SS10-14 | DS01, |  | 6+4 |
| (Bertino et al., 2008) | SS10-14 | DS01, |  | (ws <2010) |
| (Samaras et al., 2013) | SS10-14 | DS01, |  | 6+3+4 |
| (Heydari et al., 2011) | SS10-14 | DS01, |  | 6+2+4 |
| (Onut, 2012) | SS10-14 | DS01, |  | 6+2+4 |
| (Onut et al., 2011) | SS10-14 | DS01, |  | 6+2+4 |
| (Daclin et al., 2016) | SS10-14 | DS02, |  | 10+6+8+2+18 |
| (Noran, 2014) | SS10-14 | DS02, |  | 8+3+8+2+18 |
| (KeimDeitchman, 2016) | SS10-14 | DS02, |  | 8+6+4 |
| (Tomaszewski, 2011) | SS10-14 | DS02, |  | 10+2+4+12 |
| (Serrao-Neumann et al., 2015) | SS10-14 | DS02, |  | 10+5+8+12 |
| (Whittaker et al., 2015) | SS10-14 | DS02, | yes | 10+5+4+2+12 |
| (Mothershead, 2016) | SS10-14 | DS02, | yes | 8+6+4+12 |
| (Cinque et al., 2015) | SS10-14 | DS02, |  | 6+5+4+22 |
| (FakhruddinChivakidakarn, 2014) | SS10-14 | DS02, |  | 10+4+8+2+12 |
| (Frosali et al., 2015) | SS10-14 | DS02, |  | 8+5+8+2+22 |
| (AbdallaLi, 2010) | SS10-14 | DS02, |  | 10+2+4+12 |
| (Xie et al., 2016) | SS10-14 | DS02, |  | 10+6+8+22 |
| (Alamdar et al., 2016) | SS10-14 | DS02, |  | 10+6+8+2+22 |
| (RifinoMahon, 2016) | SS10-14 | DS02, |  | 8+6+4+12 |
| (Noran, 2012) | SS10-14 | DS02, |  | 6+2+4+10 |
| (Tesei et al., 2012) | SS10-14 | DS02, | Yes | 6+2+4+2+12 |
| (Keim, 2006) | SS10-14 | DS02, |  | 8+4 |
| (CanevaMarghella, 2016) | SS10-14 | DS02, |  | 8+6+4 |
| (Zdravković et al., 2014) | SS10-14 | DS02, |  | 6+3+4+10 |
| (SeppänenVirrantaus, 2015) | SS10-14 | DS02, |  | 10+5+4+22 |
| (Zschockede León, 2010) | SS10-14 | DS03, |  | 8+2+4+25 |
|  | SS10-14 | DS03, |  | 8+2+4+25 |

DS02 -> if we navigate on the results pages, we can find several papers that are probably related to this SLR. Therefore, selecting the first 20 results ordered by relevance (the default of such library) may introduce bias.

<http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-1012272426&_sort=r&_st=13&view=c&md5=a5eacd686d48c6d448b5c9795b3b38c2&searchtype=a>

(Parou aqui: ir complementando a tabela com cada DS\*. Depois que completar, fazer merge dos trabalhos (paper sobre o mesmo trabalho/projeto – usar criterio definido.)

http://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/12782/Real-Time-Forecasting-Global-Epidemics.aspx

<http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6816561&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6816561>

Inferring relations and individuals relevant to a situation: An example

<http://link.springer.com/chapter/10.1007/978-3-319-11391-3_9>

Inference and Ontologies

<http://vistology.com/publications/>

Roman, V., Moskal, J. J., Kokar, M. M., Guseman, R. P., Normoyle, R. B., Scheidt, D. Reusability of Knowledge for Deriving Latent Situational Information in EW Scenarios, to appear in MILCOM 2016.

<http://life.uni-leipzig.de/en/scientific_community/publications/publikationen_2016.html>

<http://cordis.europa.eu/project/rcn/92923_en.html>

OASIS : Open Advanced System for dIsaster and emergency management

Funded under: FP6-IST

From 2004-09-01 to 2008-12-31

Total cost: EUR 19 378 058

Coordinated in: France

Topic(s): IST-2002-2.3.2.9 - Improving Risk management

Call for proposal: FP6-2003-IST-2See other projects for this call

Funding scheme: IP - Integrated Project

Seamless response to cross-border emergency situations

If a major natural disaster were to strike several European countries simultaneously, coordinating emergency relief efforts across borders could be a nightmare.

But, in the not too distant future, local, regional and Europe-wide cooperation between civil protection organisations and emergency services should be well organised and relatively seamless, thanks to an ongoing EU research project.

At the moment, language and widely differing technologies are barriers to a harmonised approach. This is not just a cross-border problem, but also a regional and inter-service one within countries.

<http://cordis.europa.eu/result/rcn/181822_en.html>

<http://www.idira.eu/>

IDIRA (Interoperability of data and procedures in large-scale multinational disaster response actions)

Funded under: FP7-SECURITY

The IDIRA project conceptualized, developed, demonstrated and assessed approaches to facilitate coordination of large-scale disaster situations by improved interoperability. Several layers have been considered: from physical communication over semantic information interoperability up to the information interoperability on the application layer.

Main focus has been to provide a common operational picture for all stakeholders involved. A system for the exchange of the most relevant information during crises aftermath - among them information on incidents, alerts, resources, missing persons and urgent needs - has been designed and implemented. IDIRA helps to overcome language barriers and achieve technical interoperability.

Data exchange is based on standards as EDXL-RM, EDXL-SitRep and EDXL-CAP which are well known.

#### Round 3. Existing treatments for interoperability issues in EWS

Quantitative analysis:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Database / Search string** | **DS01** | **DS02** | **DS03** | **DS04** | **DS05** | **DS06** | **DS07** | **DS62** |
| [**ACM Digital Library**](http://dl.acm.org/) | [**Science Direct**](http://www.sciencedirect.com/) | [**Springer**](http://link.springer.com/search?query=%22emergency+management%22) | [**Google Scholar**](https://scholar.google.com/) | [**IEEExplore**](http://ieeexplore.ieee.org/) | [**Citeseer library**](http://citeseerx.ist.psu.edu/) | [**Scopus**](http://www.scopus.com/) | [Wiley](http://onlinelibrary.wiley.com/) |
| **Round 3** | [0](http://dl.acm.org/results.cfm?query=%28%22early+warning+systems%22%29+%26%26+%28%22interoperability%22%29+%26%26+%28%22emergency+management%22+%7C%7C+%22disaster+risk+reduction%22+%7C%7C+%22situation+awareness%22+%7C%7C+%22disaster+management%22+%7C%7C+%22crisis+management%22%29&Go.x=37&Go.y=12) | [47](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-1012283647&_sort=r&_st=13&view=c&md5=5b54fb13c39e4d433de64aaacee8f71d&searchtype=a) | [107](http://link.springer.com/search?query=%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29) | [12](https://scholar.google.nl/scholar?q=%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&btnG=&hl=pt-BR&as_sdt=0%2C5) | [0](http://ieeexplore.ieee.org/search/searchresult.jsp?queryText=.LB..QT.early%20warning%20systems.QT..RB.%20and%20.LB..QT.interoperability.QT..RB.%20and%20.LB..QT.emergency%20management.QT.%20or%20.QT.disaster%20risk%20reduction.QT.%20or%20.QT.situation%20awareness.QT.%20or%20.QT.disaster%20management.QT.%20or%20.QT.crisis%20management.QT..RB.&newsearch=true) |  | [58](https://www.scopus.com/results/results.uri?numberOfFields=0&src=s&clickedLink=&edit=&editSaveSearch=&origin=searchbasic&authorTab=&affiliationTab=&advancedTab=&scint=1&menu=search&tablin=&searchterm1=%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&field1=ALL&dateType=Publication_Date_Type&yearFrom=Before+1960&yearTo=Present&loadDate=7&documenttype=All&subjects=LFSC&_subjects=on&subjects=HLSC&_subjects=on&subjects=PHSC&_subjects=on&subjects=SOSC&_subjects=on&st1=%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&st2=&sot=b&sdt=b&sl=186&s=ALL%28%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29%29&sid=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A30&searchId=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A30&txGid=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A3&sort=plf-f&originationType=b&rr=) | 23 |

DS01:

("early warning systems") && ("interoperability") && ("emergency management" || "disaster risk reduction" || "situation awareness" || "disaster management" || "crisis management")

DS02-DS07, DS62 (unless DS06):

("early warning systems") and ("interoperability") and ("emergency management" or "disaster risk reduction" or "situation awareness" or "disaster management" or "crisis management")

<http://adsabs.harvard.edu/abs/2010EGUGA..1211172L>

Application of SOA (Service Oriented Architecture) in Early Warning Systems for Tsunamis and other Natural Hazards

Using the Common Alerting Protocol (CAP) [7] and Emergency Data Exchange Language (EDXL) [8] enables the re-usage for all kind of emergency messages.

<https://sites.google.com/site/erwinfolmeronsemanticstandards/list-of-semantic-standards>

SemanticStandards.org

List of Semantic Standards

#### Round 4. Literature reviews about interoperability in EWS

Quantitative analysis:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Database / Search string** | **DS01** | **DS02** | **DS03** | **DS04** | **DS05** | **DS06** | **DS07** | **DS62** |
| [**ACM Digital Library**](http://dl.acm.org/) | [**Science Direct**](http://www.sciencedirect.com/) | [**Springer**](http://link.springer.com/search?query=%22emergency+management%22) | [**Google Scholar**](https://scholar.google.com/) | [**IEEExplore**](http://ieeexplore.ieee.org/) | [**Citeseer library**](http://citeseerx.ist.psu.edu/) | [**Scopus**](http://www.scopus.com/) | [Wiley](http://onlinelibrary.wiley.com/) |
| **Round 4** | 0 | [6](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-1012288385&_sort=r&_st=13&view=c&md5=738824e2e8b34e20d22d4ca56e8b3e2f&searchtype=a) | [4](http://link.springer.com/search?query=%28%22literature+review%22%29+and+%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29) | [3](https://scholar.google.nl/scholar?q=%28%22literature+review%22%29+and+%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&btnG=&hl=pt-BR&as_sdt=0%2C5) | 0 |  | [1](https://www.scopus.com/results/results.uri?numberOfFields=0&src=s&clickedLink=&edit=&editSaveSearch=&origin=searchbasic&authorTab=&affiliationTab=&advancedTab=&scint=1&menu=search&tablin=&searchterm1=%28%22literature+review%22%29+and+%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&field1=ALL&dateType=Publication_Date_Type&yearFrom=Before+1960&yearTo=Present&loadDate=7&documenttype=All&subjects=LFSC&_subjects=on&subjects=HLSC&_subjects=on&subjects=PHSC&_subjects=on&subjects=SOSC&_subjects=on&st1=%28%22literature+review%22%29+and+%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29&st2=&sot=b&sdt=b&sl=212&s=ALL%28%28%22literature+review%22%29+and+%28%22early+warning+systems%22%29+and+%28%22interoperability%22%29+and+%28%22emergency+management%22+or+%22disaster+risk+reduction%22+or+%22situation+awareness%22+or+%22disaster+management%22+or+%22crisis+management%22%29%29&sid=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A30&searchId=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A30&txGid=CEF17C61FB99EB883F83891EB1A94725.zQKnzAySRvJOZYcdfIziQ%3A3&sort=plf-f&originationType=b&rr=) | 5 |

DS01:

("literature review") && ("early warning systems") && ("interoperability") && ("emergency management" || "disaster risk reduction" || "situation awareness" || "disaster management" || "crisis management")

DS02-DS07, DS62 (unless DS06):

("literature review") and ("early warning systems") and ("interoperability") and ("emergency management" or "disaster risk reduction" or "situation awareness" or "disaster management" or "crisis management")

<https://joinup.ec.europa.eu/asset/eia/asset_release/eira-v100#download-links>

European Interoperability Reference Architecture (EIRA)

The European Interoperability Reference Architecture (EIRA), is an architecture content metamodel defining the most salient architectural building blocks (ABBs) needed to build interoperable e-Government systems. The EIRA provides a common terminology that can be used by people working for public administrations in various architecture and system development tasks. The EIRA was created and is being maintained in the context of Action 2.1 of the ISA Programme. The EIRA uses (and extends) the ArchiMate language as a modelling notation and uses service orientation as an architectural style. The EIRA is aligned with the European Interoperability Framework (EIF) and complies with the context given in the European Interoperability Strategy (EIS).

#### Round 5. EWS functions and architectures

Quantitative analysis:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Database / Search string** | **DS01** | **DS02** | **DS03** | **DS04** | **DS05** | **DS06** | **DS07** | **DS62** |
| [**ACM Digital Library**](http://dl.acm.org/) | [**Science Direct**](http://www.sciencedirect.com/) | [**Springer**](http://link.springer.com/search?query=%22emergency+management%22) | [**Google Scholar**](https://scholar.google.com/) | [**IEEExplore**](http://ieeexplore.ieee.org/) | [**Citeseer library**](http://citeseerx.ist.psu.edu/) | [**Scopus**](http://www.scopus.com/) | [Wiley](http://onlinelibrary.wiley.com/) |
| **Round 5** | 0 |  |  |  |  |  |  |  |

SS55:

("disaster risk reduction") and ("early warning systems") and ("interoperability") and ("emergency management" or "disaster risk reduction" or "situation awareness" or "disaster management" or "crisis management")

SS56-57:

("early warning systems") and ("interoperability") and ("emergency management" or "disaster risk reduction" or "situation awareness" or "disaster management" or "crisis management") and (("function" OR "capability" OR "role" OR "mission" OR "goal" OR "requirement") or ("architecture" OR "framework"))

(("disaster risk reduction") and ("early warning systems") and ("interoperability")) or

(("early warning systems") and ("interoperability") and ("emergency management" or "disaster risk reduction" or "situation awareness" or "disaster management" or "crisis management") and (("function" OR "capability" OR "role" OR "mission" OR "goal" OR "requirement") or ("architecture" OR "framework")))

("early warning systems") and ("interoperability") and ("function" OR "architecture" OR "framework")

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ID | Database | SS55 | SS56 | SS57 |
| DS01 | [ACM Digital Library](http://dl.acm.org/) | [0](http://dl.acm.org/results.cfm?within=owners.owner%3DHOSTED&srt=_score&query=%22disaster+risk+reduction%22+%26%26+%22early+warning+system%22&Go.x=37&Go.y=9) | [28](http://dl.acm.org/results.cfm?within=owners.owner%3DHOSTED&srt=_score&query=%22early+warning+system%22+%26%26+%28%22function%22+%252B+%22capability%22+%252B+%22role%22+%252B+%22mission%22+%252B+%22goal%22+%252B+++%22requirements%22%29&Go.x=24&Go.y=8) | [11](http://dl.acm.org/results.cfm?within=owners.owner%3DHOSTED&srt=_score&query=%22early+warning+system%22+%26%26+%28%22architecture%22+%252B+%22framework%22%29&Go.x=35&Go.y=4) |
| DS02 | [Science Direct](http://www.sciencedirect.com/) | [254](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-968612241&_sort=r&_st=13&view=c&md5=6a50e96896e5aa3b55cc2b3ca2b63dc5&searchtype=a) | [6926](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-968629502&_sort=r&_st=13&view=c&md5=a647469a32a5ac35944a1c9e904fb851&searchtype=a) | [3336](http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=-968641080&_sort=r&_st=13&view=c&md5=ef9e8afdeaa3579c3de83202e7eee0bf&searchtype=a) |
| DS03 | [Springer](http://link.springer.com/search?query=%22emergency+management%22) | [537](http://www.springer.com/?SGWID=0-102-24-0-0&submit=Submit&sortOrder=relevance&searchType=EASY_CDA&searchScope=onlinecontent&queryText=%22disaster+risk+reduction%22+and+%22early+warning+system%22) | [8853](http://www.springer.com/?SGWID=0-102-24-0-0&submit=Submit&sortOrder=relevance&searchType=EASY_CDA&searchScope=onlinecontent&queryText=%22early+warning+system%22+AND+%28%22function%22+OR+%22capability%22+OR+%22role%22+OR+%22mission%22+OR+%22goal%22+OR+++%22requirements%22%29) | [5199](http://www.springer.com/?SGWID=0-102-24-0-0&submit=Submit&sortOrder=relevance&searchType=EASY_CDA&searchScope=onlinecontent&queryText=%22early+warning+system%22+AND+%28%22architecture%22+OR+%22framework%22%29) |
| DS04 | [Google Scholar](https://scholar.google.com/) | [3170](https://scholar.google.nl/scholar?hl=pt-BR&q=%22disaster+risk+reduction%22+and+%22early+warning+system%22&btnG=&lr=) | [72000](https://scholar.google.nl/scholar?q=%22early+warning+system%22+AND+%28%22function%22+OR+%22capability%22+OR+%22role%22+OR+%22mission%22+OR+%22goal%22+OR+++%22requirements%22%29&btnG=&hl=pt-BR&as_sdt=0%2C5) | [42100](https://scholar.google.nl/scholar?q=%22early+warning+system%22+AND+%28%22architecture%22+OR+%22framework%22%29&btnG=&hl=pt-BR&as_sdt=0%2C5) |
| DS05 | [IEEExplore](http://ieeexplore.ieee.org) | [5](https://www.ieee.org/searchresults/index.html?cx=006539740418318249752%3Af2h38l7gvis&cof=FORID%3A11&qp=&ie=UTF-8&oe=UTF-8&q=%22disaster+risk+reduction%22+and+%22early+warning+system%22) |  |  |
| DS06 | [Citeseer library](http://citeseerx.ist.psu.edu) | [1039](http://citeseerx.ist.psu.edu/search;jsessionid=DFEFE685BFEFDDF9F9EE73B714CC862E?q=%22disaster+risk+reduction%22+and+%22early+warning+system%22&submit.x=0&submit.y=0&submit=Search&sort=rlv&t=doc) | [13889](http://citeseerx.ist.psu.edu/search?q=%22early+warning+system%22+AND+%28%22function%22+OR+%22capability%22+OR+%22role%22+OR+%22mission%22+OR+%22goal%22+OR+++%22requirements%22%29&submit.x=22&submit.y=11&submit=Search&sort=rlv&t=doc) | [10528](http://citeseerx.ist.psu.edu/search?q=%22early+warning+system%22+AND+%28%22architecture%22+OR+%22framework%22%29&submit.x=0&submit.y=0&submit=Search&sort=rlv&t=doc) |
| DS07 | [Scopus](http://www.scopus.com/) | [45](http://www.scopus.com/results/results.uri?numberOfFields=0&src=s&clickedLink=&edit=&editSaveSearch=&origin=searchbasic&authorTab=&affiliationTab=&advancedTab=&scint=1&menu=search&tablin=&searchterm1=%22disaster+risk+reduction%22+and+%22early+warning+system%22&field1=TITLE_ABS_KEY&dateType=Publication_Date_Type&yearFrom=Before+1960&yearTo=Present&loadDate=7&documenttype=All&subjects=LFSC&_subjects=on&subjects=HLSC&_subjects=on&subjects=PHSC&_subjects=on&subjects=SOSC&_subjects=on&st1=%22disaster+risk+reduction%22+and+%22early+warning+system%22&st2=&sot=b&sdt=b&sl=67&s=TITLE-ABS-KEY%28%22disaster+risk+reduction%22+and+%22early+warning+system%22%29&sid=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A40&searchId=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A40&txGid=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A4&sort=plf-f&originationType=b&rr=) | [1645](http://www.scopus.com/results/results.uri?numberOfFields=0&src=s&clickedLink=&edit=&editSaveSearch=&origin=searchbasic&authorTab=&affiliationTab=&advancedTab=&scint=1&menu=search&tablin=&searchterm1=%22early+warning+system%22+AND+%28%22function%22+OR+%22capability%22+OR+%22role%22+OR+%22mission%22+OR+%22goal%22+OR+%22requirements%22%29&field1=TITLE_ABS_KEY&dateType=Publication_Date_Type&yearFrom=Before+1960&yearTo=Present&loadDate=7&documenttype=All&subjects=LFSC&_subjects=on&subjects=HLSC&_subjects=on&subjects=PHSC&_subjects=on&subjects=SOSC&_subjects=on&st1=%22early+warning+system%22+AND+%28%22function%22+OR+%22capability%22+OR+%22role%22+OR+%22mission%22+OR+%22goal%22+OR+%22requirements%22%29&st2=&sot=b&sdt=b&sl=121&s=TITLE-ABS-KEY%28%22early+warning+system%22+AND+%28%22function%22+OR+%22capability%22+OR+%22role%22+OR+%22mission%22+OR+%22goal%22+OR+%22requirements%22%29%29&sid=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A40&searchId=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A40&txGid=C75DC) | [625](http://www.scopus.com/results/results.uri?numberOfFields=0&src=s&clickedLink=&edit=&editSaveSearch=&origin=searchbasic&authorTab=&affiliationTab=&advancedTab=&scint=1&menu=search&tablin=&searchterm1=%22early+warning+system%22+AND+%28%22architecture%22+OR+%22framework%22%29&field1=TITLE_ABS_KEY&dateType=Publication_Date_Type&yearFrom=Before+1960&yearTo=Present&loadDate=7&documenttype=All&subjects=LFSC&_subjects=on&subjects=HLSC&_subjects=on&subjects=PHSC&_subjects=on&subjects=SOSC&_subjects=on&st1=%22early+warning+system%22+AND+%28%22architecture%22+OR+%22framework%22%29&st2=&sot=b&sdt=b&sl=73&s=TITLE-ABS-KEY%28%22early+warning+system%22+AND+%28%22architecture%22+OR+%22framework%22%29%29&sid=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A40&searchId=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A40&txGid=C75DC6CD51ABB4C3CEB8C01B5AC0A425.ZmAySxCHIBxxTXbnsoe5w%3A4&sort=plf-f&originationType=b&rr=) |

<http://www.dews-online.org/>

The 2004 Boxing Day disaster drastically demonstrated the paramount need for a new generation of fast and reliable tsunami early warning systems in the Indian Ocean area and beyond. Since then substantial progress has been made to minimise the threats to human life caused by such ravaging events. With focus on Indonesia, the GITEWS project (German Indonesian Tsunami Early Warning System) started in 2005 and is performing very successful so far.

Based on the massive sensor networks installed in the scope of GITEWS, the DEWS project was created in order to design and implement an early warning system for the whole Indian Ocean and the adjacent countries based on open standards. Mainly funded by the EU, a consortium of 20 partners including public and private organisations from several EU member states and the International Cooperation Partner Countries Indonesia, Thailand and Sri Lanka are working closely together. The group is rounded by entities from New Zealand and Japan.

### Initial data synthesis

### Differences between existing reviews

## Review protocol

In this section some basic definitions, based on the above data synthesis, are described, then the research questions are adapted and the search strategy is reviewed and pruned for the conduction of the rest of this SLR.

### Basic definitions

**Definition**. Disaster Management: Is a process based on four phases: (i) prevention (mitigation) occurs before a disastrous event, where risks are assessed, prevented and mitigated, plans are made, teams and emergency equipment are prepared; (ii) preparedness also occurs before a disastrous event, being different from mitigation phase because a disaster situation is somehow forecasted and the actions to prepare for the disaster is performed; (iii) response occurs during the disaster situation, focusing on rescue, relief and salvage, as well as immediate damage assessment and protection of damaged heritage; and (iv) recovery occurs after the disaster situation is finished, when damage assessment is detailed, the restoration, repair and re-habitation are made. DM is an urgent societal need causing huge investments in R&D projects (e.g. H2020).

Synonymous: crisis management, emergency management.

**Definition**. Disaster Risk Reduction (DRR): “is the conceptual framework of elements considered with the purpose of minimizing vulnerabilities and disaster risks throughout a society in order to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, and facilitate sustainable development.

DRR is a cross-cutting and development issue. The process of DRR is a complex one consisting of political, technical, participatory and resource mobilization components. Therefore, DRR requires collective wisdom and efforts from national policy and decision makers from various government sectors, and representatives from civil society, including academic institutions, the private sector and the media.” (U. N. I. S. f. D. R. UNISDR, 2007)

**Definition**. Ontology: is a representation schema, i.e. a model that describes the formal conceptualization of a universe of discourse [Hodges, 1993], realized through schematic diagrams. Examples are: UML class diagrams (software engineering), semantic networks (artificial intelligence) and ER diagrams (database). All these models seek to represent entities, relationships, properties, rules and restrictions of a specific domain.

From [16]: “Ontologies have increasingly gained attention as a generic, formal and explicit way to ‘capture and specify the domain knowledge with its intrinsic semantics through consensual terminology and formal axioms and constraints’. They provide a formal way to represent sensor data, context, and situations into well-structured terminology, which makes them understandable, sharable, and reusable by both humans and machines. Ontologies support a set of modelling primitives to define classes, individuals, attribute properties, and object properties (i.e., relations between objects). For example, the is-a property is one of the most useful properties in modelling the abstraction level of two domain concepts: ‘Dining Room’ is-a ‘Eating Activity Space’, and ‘Pan’ is-a ‘Cooking Utensil’. Ontologies are expressive in modelling entities in a smart environment and domain concepts, including sensors, complex sensor events, a space map of the environment, user profile, objects that users interact with, and ambient information such as temperature, humidity, and sound level”

Synonymous: meta-model, model, diagram, representation.

**Definition**. Ontological approach: A methodology and/or a framework and/or a mechanism and/or an implementation and/or an analysis and/or an evaluation based on ontology (definition 2). Notice that here an ontological approach has a broader sense then it is usually referred in the literature, especially outside the formal ontology community (in majority the works refer to the use of OWL).

Synonymous: semantic web technologies, data management.

**Definition.** Situation Awareness: is the ability to recognize a situation. The notion of situation has been studied for decades in Philosophy and can be defined as limited parts of the perceived reality, i.e. a set of patterns (the state of affairs) of the observed world. “A situation is a particular configuration of a part of reality which can be understood as a whole.” [6]. The concept of situation awareness was scrutinized in Endsley’s works [7], which introduces a situation awareness theory for dynamic decision making in human factors community. This theory presents a model that organizes the situation awareness concept in three levels: (i) perception of the environmental elements (i.e. the context data) in the current situation, such as space, time and other properties of objects, e.g. a person’s temperature or a river’s throughput; (ii) comprehension (i.e. understanding) of the current situation; and (iii) projection of future status (i.e. the decision to be performed). This theory was explored in several domains, such as aviation and maritime navigation (piloting), traffic control, power grid operation and military command.

**Definition.** Situation-aware (SA) application: complex event processing…

Synonymous: Context-aware applications.

**Definition.** Epidemics: “An epidemic occurs when an infectious disease spreads rapidly to many people. For example, in 2003, the severe acute respiratory syndrome (SARS) epidemic took the lives of nearly 800 people worldwide.”

**Definition.** Pandemics: “A pandemic is a global disease outbreak. HIV/AIDS is an example of one of the most destructive global pandemics in history.

Influenza pandemics have occurred more than once. Spanish influenza killed 40-50 million people in 1918. Asian influenza killed 2 million people in 1957. Hong Kong influenza killed 1 million people in 1968.

An influenza pandemic occurs when:

* A new subtype of virus arises. This means humans have little or no immunity to it. Everyone is at risk.
* The virus spreads easily from person to person, such as through sneezing or coughing.
* The virus begins to cause serious illness worldwide. With past flu pandemics, the virus reached all parts of the globe within six to nine months. With the speed of air travel today, public health experts believe an influenza pandemic could spread much more quickly. A pandemic can occur in waves. And all parts of the world may not be affected at the same time.”

**Definition.** Disease Outbreak:

**Definition.** Emergency (or Disaster) Management System: are ICT solutions, also termed as disaster (or emergency) management tools, that address those general end-user requirements: (i) increase people’s situation awareness by providing a holistic overview of the situations, being able to synthesize available data; (ii) enable compatibility with existing DM tools for smooth integration, in terms of interoperability; (iii) enable dynamicity in making data available; (iv) efficient organization and coordination of goods and personnel.

### Research questions revised

From the initial data synthesis, we state the design problem as:

**Can an ontology-driven situation-aware approach improve the interoperability of EWS?**

*How to* design an ontology-driven situation-aware framework *that* provides modeling of the detection of disaster situations and planned actions *so that* disaster risks are reduced *by* *the improvement of* interoperability among EWS?

1. For epidemiological surveillance?

Knowledge questions to be answered:

1. What are the existing EWS?
   1. What interoperability problems do stakeholders experience with them?
   2. What are the existing and available datasets (ontologies, databases, APIs – e.g. IoT/WSN, social media, Google)?
   3. What are the approaches to identify epidemic situations not specified a priori (at application design-time) from existing datasets?
2. What are the existing standards?
   1. How they represent a situation in their data/message models?
   2. How they characterize pre-epidemic situations (e.g. possible contagion)?
   3. How they characterize response actions (e.g. alerting, sending aids and resources, evacuating)?
   4. What implemented treatments make use of EDXL messages?
3. What are the existing ontologies?
4. What are the existing approaches based on SA?

(I’ll add this classification for each RQ - Question types (in SE):

* Assessment of the effect of a SE technology
* Assessment of a project development factor (e.g. adoption of a technology)
* Identification of cost and risk factors associated with a technology
* Identification of the impact of a technology on reliability, performance and cost
* Cost-benefit analysis of employing specific software development technologies or software applications (e.g. DSS to support DM)

(I have to revise the questions structure in respect to☺

• Population:

• Intervention:

• Comparison:

• Outcomes:

• Context:

• Experimental designs:.

(I`ll answer this checklist for research questions adequacy):

* Are they meaningful and important to all stakeholders’ requirements (practitioners and researches)?
* Do they lead to changes in software engineering practice?
* Do they Identify discrepancies between beliefs and reality? (why/which EU projects not implemented?)

### Serach strategy revised

Table 2.27: General inclusion criteria revised

|  |  |
| --- | --- |
| IC01 | Include only works published in the data sources listed. |
| IC02 | If two or more works describe the same approach, the latest or more comprehensive one is included. |
| IC03 | Include only works related to at least one of the concepts: DM, DRR, SA, interoperability and EWS. |
| IC04 | Include only works which improve interoperability and/or address integration issues and/or communtcation. |
| IC05 | Include only works written in English. |
| IC06 | Include all works published in 2016. |
| IC07 | If the result is a part of the work which does not present a summary of the work (e.g. acknowledgments, epilogue, dedication, index, etc.) then check the “whole” work (e.g. book) and include it whether it satisfies the other inclusion criteria. |

Table 2.28: General exclusion criteria revised

|  |  |
| --- | --- |
| EC01 | Exclude any databases that cannot be queried. |
| EC02 | If the same work (project or approach) is presented in another work, then exclude the oldest or the less comprehensive (see IC02). |
| EC03 | Exclude works from conferences published before 2005 |
| EC04 | Exclude works from workshops published before 2010 |
| EC05 | Exclude works where the main theme does not involve computer science |
| EC06 | Exclude works which have to be purchased (even with UT network access) |
| EC07 | Exclude works published before 2003 when the work is not a foundational theory |

#### Round 6. Ontology-driven treatments for semantic interoperability

Table 2.29: New search strings added to respond the revised questions

|  |  |
| --- | --- |
| **ID** | **Search string** |
| SS21 | “ontology” |
| SS23 | “surveillance” |
| SS24 | “decision support system” |
| SS25 | “context aware application” |
| SS26 | SS10 AND SS21 |
| SS27 | SS11 AND SS21 |
| SS28 | SS12 AND SS21 |
| SS29 | SS13 AND SS21 |
| SS30 | SS14 AND SS21 |
| SS36 | SS10 AND SS23 |
| SS37 | SS11 AND SS23 |
| SS38 | SS12 AND SS23 |
| SS39 | SS13 AND SS23 |
| SS40 | SS14 AND SS23 |
| SS41 | SS10 AND SS24 |
| SS42 | SS11 AND SS24 |
| SS43 | SS12 AND SS24 |
| SS44 | SS13 AND SS24 |
| SS45 | SS14 AND SS24 |
| SS46 | SS10 AND SS25 |
| SS47 | SS11 AND SS25 |
| SS48 | SS12 AND SS25 |
| SS49 | SS13 AND SS25 |
| SS50 | SS14 AND SS25 |

Table 2.30: Synonymous terms for early warning systems

|  |  |  |  |
| --- | --- | --- | --- |
| **Original term** | | **Replace to** | |
| SS22 | “early warning system” | SS58 | “warning system” |
| SS22 | “early warning system” | SS59 | “surveillance system” |
| SS22 | “early warning system” | SS60 | “alerting system” |
| SS22 | “early warning system” | SS61 | “multi-hazard early warning system” |

#### Round 6. Ontology-driven treatments for interoperability in emergency context

Round 2:

(Macário et al., 2009)

By comparing the second and the third search results it is clear that we succeeded in the pruning strategy. Below we present the results regarding ICT solutions:

Table 2.31: Fourth search results within digital libraries: “ontology”

|  |  |
| --- | --- |
| SS21 | “ontology” |
| SS26 | SS10 AND SS21 |
| SS27 | SS11 AND SS21 |
| SS28 | SS12 AND SS21 |
| SS29 | SS13 AND SS21 |
| SS30 | SS14 AND SS21 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ID | Database | SS26 | SS27 | SS28 | SS29 | SS30 |
| DS01 | [ACM Digital Library](http://dl.acm.org/) | 0 | 0 | 0 | 0 | 0 |
| DS02 | [Science Direct](http://www.sciencedirect.com/) | 62 | 3 | 57 | 51 | 41 |
| DS03 | [Springer](http://www.springer.com) | 146 | 7 | 159 | 155 | 119 |
| DS04 | [Google Scholar](https://scholar.google.com/) | 1,430 | 88 | 1,600 | 2,780 | 1,140 |
| DS05 | [IEEExplore](http://ieeexplore.ieee.org) | 10 | 1 | 4 | 5 | 6 |
| DS06 | [Citeseer library](http://citeseerx.ist.psu.edu) | 658 | 26 | 1,302 | 509 | 592 |
| DS07 | [Scopus](http://www.scopus.com/) | 18 | 0 | 9 | 17 | 13 |

#### Round 7. Surveillance-based treatments for interoperability in emergency

Table 2.32: Fourth search results within digital libraries: “surveillance”

|  |  |
| --- | --- |
| SS23 | “surveillance” |
| SS36 | SS10 AND SS23 |
| SS37 | SS11 AND SS23 |
| SS38 | SS12 AND SS23 |
| SS39 | SS13 AND SS23 |
| SS40 | SS14 AND SS23 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ID | Database | SS36 | SS37 | SS38 | SS39 | SS40 |
| DS01 | [ACM Digital Library](http://dl.acm.org/) | 0 | 0 |  |  |  |
| DS02 | [Science Direct](http://www.sciencedirect.com/) | 98 | 5 | 47 | 70 | 73 |
| DS03 | [Springer](http://www.springer.com) | 127 | 7 | 130 | 116 | 148 |
| DS04 | [Google Scholar](https://scholar.google.com/) | 3,000 | 161 | 2,500 | 1,990 | 3,360 |
| DS05 | [IEEExplore](http://ieeexplore.ieee.org) | 1 | 5 | 216 | 123 | 87 |
| DS06 | [Citeseer library](http://citeseerx.ist.psu.edu) | 1,477 | 81 | 2,599 | 687 | 1,076 |
| DS07 | [Scopus](http://www.scopus.com/) | 5 | 0 | 9 | 1 | 2 |

#### Round 8. Decision support systems (DSS) and interoperability in emergency

Table 2.33: Fourth search results within digital libraries: “DSS”

|  |  |
| --- | --- |
| SS24 | “decision support system” |
| SS41 | SS10 AND SS24 |
| SS42 | SS11 AND SS24 |
| SS43 | SS12 AND SS24 |
| SS44 | SS13 AND SS24 |
| SS45 | SS14 AND SS24 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ID | Database | SS41 | SS42 | SS43 | SS44 | SS45 |
| DS01 | [ACM Digital Library](http://dl.acm.org/) |  |  |  |  |  |
| DS02 | [Science Direct](http://www.sciencedirect.com/) | 56 | 3 | 19 | 45 | 25 |
| DS03 | [Springer](http://www.springer.com) | 112 | 6 | 63 | 71 | 78 |
| DS04 | [Google Scholar](https://scholar.google.com/) | 969 | 83 | 572 | 965 | 565 |
| DS05 | [IEEExplore](http://ieeexplore.ieee.org) | 2 | 2 | 2 | 1 | 1 |
| DS06 | [Citeseer library](http://citeseerx.ist.psu.edu) | 671 | 53 | 846 | 431 | 420 |
| DS07 | [Scopus](http://www.scopus.com/) | 13 | 0 | 8 | 14 | 12 |

#### Round 9. Context-aware treatments for interoperability in emergency

Table 2.34: Fourth search results within digital libraries: “context aware application”

|  |  |
| --- | --- |
| SS25 | “context aware application” |
| SS46 | SS10 AND SS25 |
| SS47 | SS11 AND SS25 |
| SS48 | SS12 AND SS25 |
| SS49 | SS13 AND SS25 |
| SS50 | SS14 AND SS25 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ID | Database | SS46 | SS47 | SS48 | SS49 | SS50 |
| DS01 | [ACM Digital Library](http://dl.acm.org/) |  |  |  |  |  |
| DS02 | [Science Direct](http://www.sciencedirect.com/) | 7 | 0 | 6 | 4 | 1 |
| DS03 | [Springer](http://www.springer.com) | 5 | 0 | 28 | 10 | 6 |
| DS04 | [Google Scholar](https://scholar.google.com/) | 34 | 1 | 99 | 38 | 26 |
| DS05 | [IEEExplore](http://ieeexplore.ieee.org) | 0 | 0 | 9 | 4 | 1 |
| DS06 | [Citeseer library](http://citeseerx.ist.psu.edu) | 65 | 0 | 216 | 48 | 51 |
| DS07 | [Scopus](http://www.scopus.com/) | 0 | 0 | 0 | 0 | 0 |

#### Round 10. Interoperability issues in multi-hazard EWS (MHEWS)

“multi-hazard EWS” (MHEWS)

#### Round 11. Interoperability issues in epidemics and public health monitoring

Found in the round:

Round 2:

(Ortega et al., 2010)

“public health surveillance system”

“health interoperability”

“global disease monitoring”

“disease surveillance”

“disease detection"

“digital surveillance system”

“epidemics surveillance”

“global warning infrastructures”

“epidemic detection” and “sensors”

“Google Public Alerts” and “epidemics”

“alert publishing tool” and “epidemics”

“alert publishing system” and “epidemics”

“commercial mobile alert system” and “epidemics”

“emergency alert system” and “epidemics”

“pandemic”

“disease”

“disease outbreak”

“epidemiology”

“epidemic detection” and “decision support system”

“epidemic monitoring”

“epidemic surveillance”

“prevention of outbreak”

“patient tracking system”

“Electronic Patient Record system” (EPR)

#### Round 12. Interoperability issues in eHealth

“eHealth”

“Medical practice management software”

“tele-health”

“Electronic Patient Record (EPR)”

“Electronic Health Record (EHR)”

“patient tracking systems”

<http://www.semantichealthnet.eu/>

Project full title: Semantic Interoperability for Health Network

The SemanticHealthNet project is partially funded by the European Commission.

FP7 on CORIDS website

Budget: 3.222.380 EURO

Start: 01.12.2011

End: 31.05.2015

<http://www.ihe.net/>

Integrating the Healthcare Enterprise (IHE)

IHE is an initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information. IHE promotes the coordinated use of established standards such as DICOM and HL7 to address specific clinical needs in support of optimal patient care. Systems developed in accordance with IHE communicate with one another better, are easier to implement, and enable care providers to use information more effectively.

<http://www.continuaalliance.org/>

The Personal Connected Health Alliance (PCHA) is a membership association formed by Continua, mHealth Summit and HIMSS to transform healthcare through personalized, interoperable connected health solutions. PCHA engages in three broad areas of activity:

<http://www.en13606.org/>

The main aim of this Association is to become a meeting point and the prime source of information about the CEN/ISO 13606 EHR standard for healthcare providers, hospitals, IT-vendors and regional and national projects. At the same time, to pave the way for a next release of the CEN/ISO EN13606 EHRcom standard based on existing implementation experiences.

The association as a not-for-profit organisation with open membership.

#### Terms to be considered during the treatment design

“social big data”

“social media”

“crisis informatics”

“emergency management information systems”

“situation awareness application” or “situation aware application”

“Conceptual model”

“Complex event processing”

“Big data”

“Model driven engineering” or “model driven architecture”

“Distributed systems”

“Service-oriented architecture”

“smart city”

“smart home”

“pervasive computing”

“situation modeling”

“CEML” (Crisis and emergency Modeling Language)

“EM-DAT” (disastrous events database)

“Google Public Alerts”

“OASIS” and “EDXL”

“HL7” and “FHIR” (Fast Health Interoperability Resources)

“information exchange framework” (OMG standard)

“HealthMap.org”

“BioMosaic”

“FIA” (Federation for Internet Alerts)

Papers that must be included:

<https://www.researchgate.net/publication/302553766_Improving_Situation_Awareness_in_Crisis_Response_Teams_an_Experimental_Analysis_of_Enriched_Information_and_Centralized_Coordination>

<http://www.bioontology.org/technology/ontology-library>

<http://bioportal.bioontology.org/ontologies/SWEET>

<http://sweet.jpl.nasa.gov/2.3/phenBiol.owl#Epidemic>

<http://www.bioinf.jku.at/publications/ifs/2010/dke-beaware.pdf>

ScienceDirect: “interoperability” + “model-driven engineering”:

<http://www.sciencedirect.com/science/article/pii/S0166361515300191>

Wiley: "infectious disease" and "integrated warning system":

<http://onlinelibrary.wiley.com/doi/10.15252/embr.201642534/abstract>

<https://www.researchgate.net/publication/264428214_Mobile_situation-aware_framework_for_developing_smart_mobile_software>

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC212776/>

(Technical Description of RODS: A Real-time Public Health Surveillance System)

Real-time Outbreak and Disease Surveillance (RODS) system.

# Conducting

Based on the protocol described in the planning phase, the proper detailed review is presented here, along with any needed adaptation.

## Identification of research

In this phase the search strategy is

Search strategy

Publication bias

Bibliography management and document retrieval

Documenting the search

Lessons learned for search procedures

## Study selection

In this section we describe the search strategy adopted in this SLR, justifying it as an appropriate choice for the research question [2].

Study selection criteria

Study selection process

Reliability of inclusion decisions

## Study quality assessment

The hierarchy of evidence

Development of quality instruments

Using the quality instrument

Limitations of quality assessment

Table: (pg.25) Quality checklist for quantitative studies

## Data extraction

Design of data extraction forms

Contents of data collection forms

Data extraction procedures

Multiple publications of the same data

Unpublished data

Lessons learned

## Data synthesis

Descriptive synthesis

Quantitative synthesis

Presentation of quantitative results

Qualitative synthesis

Synthesis of qualitative and quantitative studies

Sensitivity analysis

Publication bias

Lessons learned

# Reporting

The summary of the SLR, maybe in the format of a journal paper.

# Conclusion

TODO

## Contributions

TODO

## Limitations

TODO

## Future work

TODO

# Appendix

## Scientific literature sources

Table 2.3: Journals

|  |  |  |
| --- | --- | --- |
| ID | Journal | Impact factor |
| DS21 | [Epidemics](http://www.journals.elsevier.com/epidemics/) | 1.578 |
| DS08 | [International Journal of Emergency Management](http://www.inderscience.com/jhome.php?jcode=ijem) | 17 (H-index) |
| DS09 | [Journal of Emergency Management](http://www.emergencymanagementjournal.com) |  |
| DS10 | [Disasters](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-7717) | 0.742 |
| DS11 | [Disaster Prevention and Management](http://www.emeraldinsight.com/journal/dpm) | 0.987 |
| DS12 | [Australian Journal of Emergency Management](https://ajem.infoservices.com.au/) | 18 (H-index) |
| DS13 | [DomPrep Journal](http://www.domesticpreparedness.com/DomPrep_Journal/) |  |
| DS14 | [International journal of mass emergencies and disasters](http://www.ijmed.org/) |  |
| DS15 | [Journal of contingency and crisis management](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1468-5973) | 1.073 |
| DS16 | [Journal of homeland security and emergency management](http://www.degruyter.com/view/j/jhsem) | 0.760 |
| DS17 | [**International Journal of Disaster Risk Reduction**](http://www.journals.elsevier.com/international-journal-of-disaster-risk-reduction/) | **1.242** |
| DS18 | [Journal of the International Society for the Prevention and Mitigation of Natural Hazards](http://www.springer.com/earth+sciences+and+geography/natural+hazards/journal/11069/PSE) | 1.746 |
| DS19 | [International Journal of Disaster Risk Science](http://www.springer.com/earth+sciences+and+geography/natural+hazards/journal/13753) | 0.462 |
| DS20 | [Journal of International Humanitarian Action](http://www.springer.com/law/international/journal/41018) |  |
| DS22 | [Network Modeling Analysis in Health Informatics and Bioinformatics](http://www.springer.com/computer/information+systems+and+applications/journal/13721) |  |
| DS23 | [Disaster and Military Medicine](http://www.disastermilitarymedicine.com/) |  |
| DS24 | [Journal of Geography & Natural Disasters](http://www.omicsgroup.org/journals/geography-natural-disasters.php) | 0.714 |
| DS25 | [Journal of Disaster Research](http://www.fujipress.jp/JDR/) | 6 (H-index) |
|  | [Journal of Environmental Modelling & Software](http://www.journals.elsevier.com/environmental-modelling-and-software/) |  |
|  | [Journal of Health Informatics](http://www.jhi-sbis.saude.ws/ojs-jhi/index.php/jhi-sbis) | 0.194 |
|  | [International Journal of Epidemiology](http://ije.oxfordjournals.org/) | 3.022 |
|  | [**International Journal of Information Systems for Crisis Response and Management (IJISCRAM)**](http://www.igi-global.com/journal/international-journal-information-systems-crisis/1119) |  |

<http://library.tue.nl/catalog/OAImpact.csp>

Table 2.4: Conferences

|  |  |  |  |
| --- | --- | --- | --- |
| ID | Acronym | Name | Impact factor |
| DS53 | WCDRR | [UN World Conference on Disaster Risk Reduction](http://www.wcdrr.org/home) |  |
| DS26 | ISCRAM | [Information Systems for Crisis Response and Management](http://www.iscram.org/) |  |
| DS27 | Epidemics | [International Conference on Infectious Disease Dynamics](http://www.epidemics.elsevier.com/) |  |
| DS28 | CogSIMA | [IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support](http://cogsima2016.org/) |  |
| DS29 | WCDM | [World Conference on Disaster Management](http://www.wcdm.org/) |  |
| DS30 | ICT-DM | [IEEE International Conference on Information and Communication Technologies for Disaster Management](http://ict-dm2016.ait.ac.at/) |  |
| DS31 | TIEMS | [International Emergency Management Society](http://tiems.info/) |  |
| DS33 | IAEM | [International Association of Emergency Managers](http://www.iaemconference.info/) |  |
| DS34 | STIDS | [International Conference on Semantic Technologies for Intelligence, Defense, and Security](http://stids.c4i.gmu.edu/) |  |
| DS51 | ICCM | [International Conference of Crisis Mappers](http://crisismappers.net/) |  |
|  | IDRIM | [International Conference on Integrated Disaster Risk Management](http://idrim.org/) |  |
|  | ITDRR | [IFIP Conference on Information Technology in Disaster Risk Reduction](http://itdrr.unwe.bg/) |  |
|  | ISDS | [International Society for Disease Surveillance](http://www.syndromic.org/annual-conference/2016-isds-conference) |  |
|  | IHIC | [International HL7 Interoperability Conference](http://wiki.hl7.org/index.php?title=IHIC) |  |
| DS55 | CSCW | [ACM Conference on Computer Supported Cooperative Work & Social Computing](https://cscw.acm.org/2017/) |  |
| DS56 | IWCMC | [International Conference on Wireless Communications and Mobile Computing](http://iwcmc.org/2016/) |  |
| DS57 | SIGIR | [International ACM SIGIR conference on Research and development in information retrieval](http://sigir.org/sigir2016/) |  |
| DS58 | SummerSim | [Summer Simulation Multi-Conference](http://www.scs.org/summersim) |  |
| DS59 | WWW | [International Conference on World Wide Web](https://en.wikipedia.org/wiki/International_World_Wide_Web_Conference) |  |
| DS60 | WI | [Web Intelligence Consortium](http://wi-consortium.org/wicweb/html/confer.html) |  |
| DS61 | SACMAT | [ACM Symposium on Access Control Models and Technologies](http://www.sacmat.org/) |  |

Table 2.5: Workshops

|  |  |  |
| --- | --- | --- |
| ID | Name | Impact factor |
| DS32 | [Workshop on Information Systems for Situation Awareness and Situation Management](http://issasim.scch.at/en/) |  |

Table 2.6: Books

|  |  |  |
| --- | --- | --- |
| ID | Name | Impact factor |
| DS35 | [Disaster Studies and Management](http://www.springer.com/series/13839) |  |
| DS36 | [Emerging Infectious Diseases of the 21st Century](http://www.springer.com/series/5903) |  |
| DS37 | [Disaster Risk Reduction](http://www.springer.com/series/11575) |  |
| DS38 | [Disaster Recovery](http://link.springer.com/book/10.1007%2F978-4-431-54255-1) |  |
| DS39 | [Sustainable Development and Disaster Risk Reduction](http://link.springer.com/book/10.1007%2F978-4-431-55078-5) |  |
| DS40 | [Natural Disaster Risk Management](http://link.springer.com/book/10.1007%2F978-3-319-20675-2) |  |
| DS41 | [Prediction and Forecasting of Natural Disasters](http://link.springer.com/chapter/10.1007/978-81-322-1566-0_6) |  |
| DS42 | [Disaster Education and Management](http://link.springer.com/book/10.1007%2F978-81-322-1566-0) |  |

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24. <https://en.wikipedia.org/wiki/Disaster_risk_reduction> [↑](#footnote-ref-24)