

Towards a Core Ontology of Occupational Safety and Health

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Abstract. Occupational safety and health (OSH) is defined as the scientific domain dealing with the identification and control of hazards that emerge in or from the workplace and that may negatively impact the health and well-being of workers. In this work, we describe the modeling of the core vocabulary of the domain with a goal to establish a core OSH ontology. We discuss the issues encountered during the design process.

Key words: occupational safety and health, ontology

1 Introduction

Occupational safety and health (OSH) is defined as the scientific domain dealing with the anticipation, identification, evaluation and control of *hazards* that emerge in or from the *workplace* and that may negatively impact the *health* and well-being of *workers* [1]. It is a broad, multidisciplinary domain since a variety of workplaces and hazards exist. *World Health Organization (WHO)* considers rather the discipline of *occupational health* defined as dealing with "all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards."¹ Health is considered as a state of complete well-being and not just the absence of disease. Whereas the term *safety engineering* refers to a related engineering discipline whose goal is to ensure acceptable levels of safety provided by engineered systems. Studying the possible impact on the neighbouring communities and environment is also being considered as part of OSH.

In this work, we specify the core vocabulary of the domain with basic ontological distinctions. The ultimate goal is to establish a common vocabulary and a core formal model of the domain.

The rest of the paper is structured as follows. In Sect. 2 we review related ontologies and non-ontological resources. In Sect. 3 we describe the classes of OSHDO-Core. In Sect. 4 we provide a discussion and lessons learnt with respect to modeling the ontology in OWL [2] and ontology engineering. In Sect. 5 we provide a summary and future work agenda.

¹ http://www.wpro.who.int/topics/occupational_health/en/

2 Related Work

The occupational safety and health overlaps with a number of disciplines including safety engineering, (occupational) medicine, psychology, epidemiology, human factors and ergonomics, physiotherapy and rehabilitation, law and others. The ontologies for many of those fields exist, but focused on the particular domain. Below, we briefly review the ontologies from the overlapping domains.

The major terms in OSH are hazard (threat) and risk. Threat is considered in Internet and/or Cyber Security, and [3] describes an ontology in the latter domain, but it is modeled with a different focus and scope. The Risk base ontology from the EU project RISCOSS [4] re-uses concepts from another risk ontology, defined in the EU project Musing², definitions from standards such as ISO 31000, and terms defined in risk management methodologies. It does not include, however, a concept of hazard. There are many ontologies that might be considered relevant for modeling hazards, such as from the life sciences domain [5] which include knowledge on potential hazards - biological and chemical agents - and diseases. They may be useful in further steps for modeling OSHDO branches beyond the core module.

Legal ontologies such as LKIF-Core Ontology of basic legal concepts [6] describe the issues related to law, legislation, norms, but none of them models vocabulary typical to OSH (aspects specific to safety management, as how to implement the duties related to safety, what are the requirements for carrying out activities aimed at risk reduction etc.). Similarly, ontologies related to management or business processes [7] do not contain key concepts from the OSH domain, e.g. to describe the consequences of impacts in the labor process, prevention methods, procedures and security measures which must be used to deal with hazardous substances and situations.

Identifying and analyzing the available ontologies revealed lack of one that fully covers the scope and vocabulary for the subject of OSH. Thus we aim at creating a new ontology on the basis of available resources. To identify a set of core concepts we have examined non-ontological resources including: the taxonomy of categories of OSHwiki³, definitions from standards such as OHSAS 18001 as well as glossaries of terms⁴. We have also studied handbooks on the domain [1, 8] and the definitions therein.

3 Overview of the concepts of OHSDO-Core

In this section, we describe basic terms of OHSDO-Core v1.0. The ontology may be downloaded from <http://semantic.cs.put.poznan.pl/ontologies/oshdo/OSHD0-Core.owl>.

OccupationalSafety and Health are two important terms in the domain that are often misinterpreted. For the layperson, 'safety' is to not getting injured.

² <http://cordis.europa.eu/ist/kct/musingsynopsis.htm>.

³ <http://oshwiki.eu>

⁴ http://www.iapa.ca/pdf/iapa_glossary.pdf

But professionals operate by referring to the likelihood or risk of an occurrence of such an event. Safety is understood as "operating within an acceptable or low probability of risk" [8] that concerns potential harm to people and non-human resources of the enterprise (equipment and facilities). Similarly, Health is commonly interpreted as the absence of disease. But in the OSH domain, the broader definition, as the one of WHO (cf. Sect. 1), is adapted.

OccupationalHazard is the major term in the domain. It is defined as a *potential source* of Harm (Injury or other health deterioration) on someone or something. It is a *threat* that may be caused by source, situation, or act with a potential for harm. It may be responsible for Incidents at Workplace and/or occupational diseases (OccupationalDisease) under occurrence of a certain HazardousEvent or condition⁵. HazardousEvent is as an event where at least one participating Worker is exposed to an OccupationalHazard. HazardousEvent may casually follow some Cause and may cause one or more Consequence. OccupationalExposure is a measure of the extent (a dose) to which a Worker (or Equipment) is likely to be exposed to - or may be influenced by - the OccupationalHazard. HazardousSituation⁶ is a situation that participates in one or more HazardousEvents. It represents a 'snapshot', a setting that is associated with a HazardousEvent. There is a variety of hazards e.g., physical hazards, electrical hazards, radiation hazards, thermal hazards, noise, and vibration. HazardIdentification is one of the main areas of OSH. OccupationalExposureLimit (OEL)⁷ is the limit on the acceptable concentration of a hazardous substance in the workplace.

Risk is the term often confused with OccupationalHazard. Some dictionaries give imprecise definitions or even combine those two terms (e.g. "a danger or risk"), and many people apply those terms interchangeably. But hazard is only one of the components of Risk. Risk, in the simplest case, is the likelihood that Harm will actually occur ($Risk = Hazard \times Exposure$). A broader meaning of Risk also considers the likelihood of the amount of Harm that the exposure to a hazard will cause (Severity). For instance, [1] provides the following formula to define Risk: $Risk = Probability \times Severity$. The OHSAS 18001:2007 standard defines risk as "combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event, accident (s) or exposure(s)". Other definitions and formulas have also been proposed and it remains to be further researched what is most proper formal definition in the context of OSH. RiskAssessment concerns analyzing the risks and determining the level of acceptability of risk, based on the reviews of the risk including risk analysis and risk evaluation. It shall consider acceptable risks, for which changes are not necessary and those for which actions are needed to be taken to reduce Risk. Action is a short-term event. PreventiveAction and CorrectiveAction may be distinguished (for preventing incidents and eliminating similar incidents to those that has just happened).

⁵ <http://www.bsigroup.com/en-GB/ohsas-18001-occupational-health-and-safety/>

⁶ the Hazardous Situation Ontology Design Pattern is described at <http://ontologydesignpatterns.org/wiki/Submissions:HazardousSituation> and in [9]

⁷ EuropeanAgencyforSafetyandHealthatWork. "OccupationalExposureLimits"<https://osha.europa.eu/en/topics/ds/>

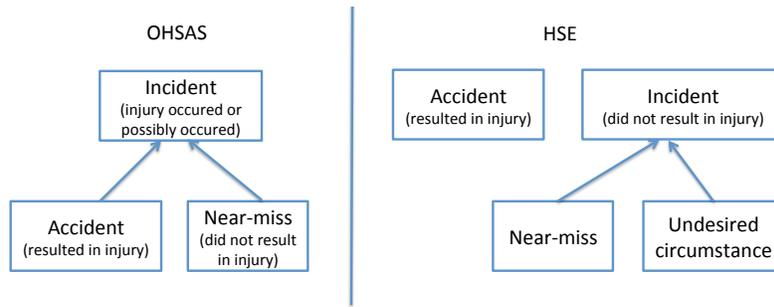


Fig. 1. Accident as an event of type of Incident (according to OHSAS versus Accident and Incident as different type of events (according to HSE⁹).

Harm occurs in practice when there are both: the OccupationalHazard and OccupationalExposure. It may be a result of Incident or Accident at Workplace causing negative consequences for the life and health of a Worker or Equipment. OccupationalDisease⁸ is primarily a result of OccupationalExposure to risk factors in the Workplace arising from specificity of tasks that Worker performs.

Various definitions of Incident and Accident, regarded as unintended events at work, exist in the literature (see: Figure 1). We adopt the definition of Incident from OHSAS 18001 standard, where Incident is regarded as "a work-related event(s) in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred"¹⁰. Those events are nearly always preceded by unsafe acts of workers, hazardous conditions in the workplace, or both.

Worker is a physical person employed by an employer to carry out the tasks laid down in the contract of employment. Employer is a physical or legal person that operates under law with regard to an employment relationship with the Worker. From a safety standpoint Employer is responsible for the condition of the company as well as for activities that must be performed in order to identify and minimize risks. Workplace is the physical location and its surroundings where the Worker takes actions related to performing any work that is organized by the management and subject to ongoing monitoring. Workplace also includes machines (Machine), equipments Equipment and tools needed to do the job. Hazardous environment at work associated with unsafe conditions, i.e. such conditions, not directly caused by the action or inaction of one or more workers in an area, that may lead to an Incident or Injury if uncorrected. It may be caused by faulty design, incorrect fabrication or construction, or inadequate maintenance and subsequent deterioration.

OSH-Policy is defined by OHSAS 18001:2007 as "overall intentions and direction of an organization related to its OH&S performance as formally expressed by top management". It is a method for guiding carrying out actions. It states

⁸ http://www.who.int/occupational_health/activities/occupational_work_diseases/en

¹⁰ <http://www.ohsas-18001-occupational-health-and-safety.com>

the principles and rules to guide actions. **PreventionStrategy** and **ControlStrategy** are both plans of actions such as, for instance, related to personal protective equipment, or workplace health promotion. **OSH-Management** is a geared effort of reducing the risk into acceptable threshold level, then keep it at the same or lower level. The safety management system **OSH-ManagementSystem** is regarded as a set of functions that are decisive in defining and implementing security policies in the workplace. **OSH-Performance** is a measurable, definite in time score indicating the level of the performance of the company in terms of OSH after the implementation of work safety management system. **PreventiveMeasure** and **ProtectiveMeasure** are used to assess, prevent and reduce occupational Risk. Efforts are made where risk assessment indicates an inadmissible level of risk to reduce it and improve the **Workplace**.

SafetyDataSheet describes a substance (its degree of toxicity, storage, reactivity and composition) and procedures for using it in a safe manner, and for emergency actions when misuse of the substance occurs.

4 Discussion

During this and previous ontology engineering efforts [10], we have identified some needs with regard to the ontology modeling language and ontology editors:

1. support for Ontology Design Patterns [11]; this includes support for handling groups of axioms, rather than individual axioms, analogously to handling composite objects in vector graphics editors after 'grouping' operation to manipulate multiple axioms collectively;
2. support for axiom generalisations, i.e. for templates of recurring modeling in axioms, where some entities in an axiom are replaced by variables (see for instance [12]). This should enable an ontology engineer to work at the level of the pattern (as with OPPL [13]) and not that of the set of OWL axioms. Such templates could be used as macros to facilitate ontology population (as with Populous tool [14], for instance);
3. support for provenance-aware versioning, i.e. use of provenance vocabulary [15] with some ontology change vocabulary [16] to track entity provenance (what was created by whom etc.), facilitate querying provenance, and 'roll-back' operations.

5 Summary and Future Work

In this paper, we have presented version v1.0 of the core module of the Occupational Safety and Health Domain Ontology (OSHDO-Core).

Next steps of the future work agenda include investigating, selecting and modeling further ontology design patterns that may be included into the ontology. We plan to further enhance the scope and the axiomatisation of the ontology.

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