



Review

Safety management systems: A broad overview of the literature

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ABSTRACT

This paper describes safety management systems (SMSs) on five core aspects: definition, evolution, models, purpose and common elements of SMSs. A safety management system implements safety management activities, so an overview of definitions of safety and safety management sheds light on the content of an SMS. SMSs emerged from the risk concept and safety defences. The development of SMSs was boosted by research into 'safety', 'management' and 'system' theories, (safety) risk analysis techniques, safety audit tools, and related standards. Consequently, the study of SMSs became a multidisciplinary topic and through modelling SMSs, a generic framework can be established aiding the effectiveness of SMSs.

There are two main groups of models informing SMSs: (1) accident related models, and (2) organisational models. The relationship between these two models is outlined in this paper. Moreover, we discuss that SMSs studies and models are developed for two main purposes: control and compliance. To control means by implementing safety systems or subsystems, an SMS is able to control risks and to improve continuously, as well as comply with the appropriate standard management systems. As the key to implementing a functional SMS is to carry out common managerial processes, we map the elements of various SMSs to a generic SMS to explore the extent to which they correspond. Like a diamond needs to be cut with facets to show its brilliance, this paper intends to determine and clarify the 'facets' of an SMS, and to distinguish all issues clear-cut for the modelling of an SMS.

1. Introduction: overview approach and objective

A safety management system (SMS) is either a system that is used to manage and control safety or it is a management system specifically aimed at safety. Taking three perspectives, i.e. safety, management and system, an SMS is the intersection of these. How an SMS evolves over time depends to some extent on the individual progress of each of these three aspects. Safety primarily focuses on its opposite, i.e. accidents, loss or injuries, which are often described using models and metaphors (see Swuste et al., 2010, 2011). The terms management and system both have broad meanings: management involves planning, organising, leading and controlling functions (Robbins and Judge, 2012); the elementary principle of a system is input–process–output (Hale et al., 1997; Hammer, 1971; Waring, 1996).

The following steps were taken for this overview (Fig. 1):

1. Select keywords and databases; initial keywords used were 'safety', 'management' and 'system';
2. Filter the outcome using the resulting titles;
3. Extract papers;

4. First bibliometric analysis of texts (e.g. abstract);
5. Refine overview sources.

Although the term SMS is widely used, its definition, scope, modelling and purpose still need to be clearly defined. To gain insight into the origins and development of SMSs, this paper will focus on the following five questions.

1. What is an SMS? (Definition)
2. How does an SMS evolve? (History)
3. How are SMSs modelled? (Model)
4. What are SMSs used for? (Purpose)
5. What are the constituting elements of SMSs? (Elements)

2. Definition of an SMS

2.1. Definition of safety

Safety is a broad and abstract concept, which is best described in terms of a particular state or situation (Table 1). This state is freedom

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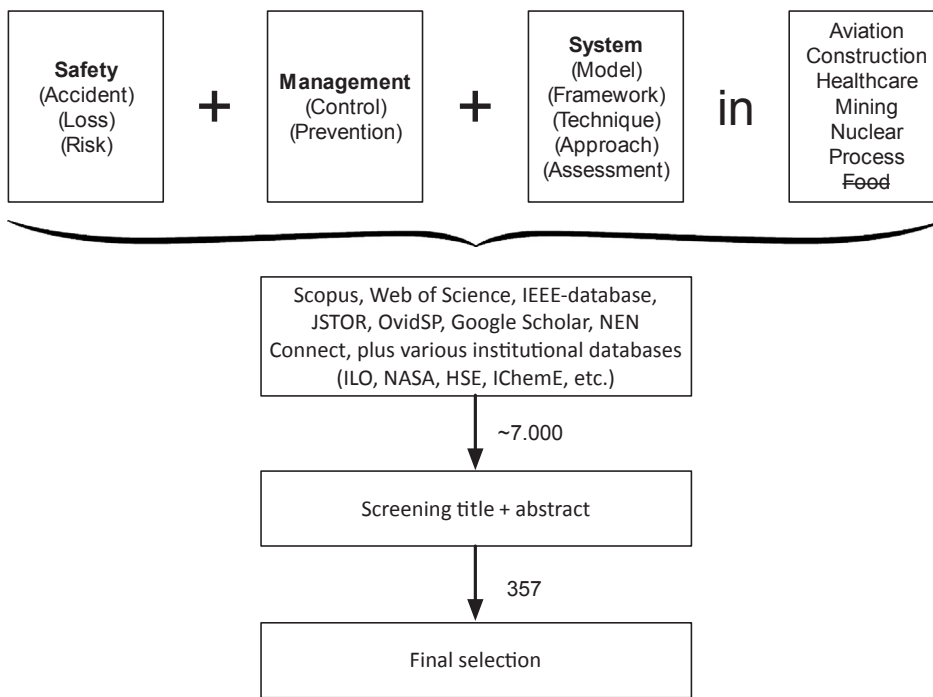


Fig. 1. Procedure for selection of papers for overview.

Table 1
Safety management system definitions.

Authors	Industry	Definition
Kysor, 1973		A Safety Management System (SMS) can be defined as a planned, documented safety program that incorporates certain basic management concepts and activating elements into a well-organized safety system. The safety activity areas and supporting elements that comprise this system act and interact on one another to help achieve the desired safety level or risk level. A total safety management system consists of objects: parameters such as input, process, output, and feedback control; attributes: properties of parameters such as the external manifestation of the way in which an object is known, observed, or introduced in a process; relationships: bonds that link objects and attributes in the system process
Carrier, 1993	Offshore	ADCQ's Safety Management System (SMS): a system designed to cover a broad band of safety activities and provide positive management control
Waring, 1996	General	Functionalist/engineering world view: a set of documented procedures or people using such a set of procedures Interpretive world view: a human activity system including control monitoring communication, operational and other elements as well as complex human factors
IAEA, 1999	Nuclear	The safety management system comprises those arrangements made by the organisation for the management of safety in order to promote a strong safety culture and achieve good safety performance
Mitchison and Papadakis, 1999	Legislation (directive)	A Safety Management System (SMS) is defined in the Directive (Seveso II) as including 'the organisational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the major-accident prevention policy', in other words the system for implementing safety management
Edwards, 1999; Hsu et al., 2010	Aviation	A safety management system is no more than a systematic and explicit approach to managing safety – just as a quality management system is a systematic and explicit approach to improving the quality of a product to meet the customer's requirement
DOE	Energy	Safety Management Systems provide a formal, organized process whereby people plan, perform, assess, and improve the safe conduct of work. The Safety Management System is institutionalized through Department of Energy (DOE) directives and contracts to establish the Department-wide safety management objective, guiding principles, and functions
Ivan et al., 2003	Transport	A highway Safety Management System (SMS) is a systematic process designed to assist decision makers in selecting effective strategies to improve the efficiency and safety of the transportation system
ERA, 2007	Railway	Safety management system means the organisation and arrangements established by an infrastructure manager or a railway undertaking to ensure the safe management of its operations
ICAO, 2007	Aviation	A safety management system (SMS) is an organized approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures
Stolzer, 2008	Aviation	A dynamic risk management system based on quality management system (QMS) principles in a structure scaled appropriately to the operational risk, applied in a safety culture environment
Waddington et al., 2009	Aviation & Nuclear	Safety Management System (SMS) approach aimed at harmonizing, rationalizing and integrating management processes, safety culture and operational risk assessment
Thomas, 2011	Transport	Modern SMS could be defined as an arbitrary collection of activities that were deemed necessary actions to discharge responsibilities under the new age of the delegated responsibility of self-regulation

from 'something' that could have negative consequences, such as harm to humans or animals, economic loss, or any other form of damage or loss. In other words, safety is the condition whereby unexpected events, such as accidents and incidents, are being avoided. In specific contexts,

safety can be defined in more practical terms. For example, in a hospital, the safety of patients means keeping patients in a stable condition by avoiding the risk of adverse events (Shojania et al., 2001).

This paper is concerned with industrial safety; hence, the

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